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EUSTON SQUARE STATION.



RAILWAY APPLIANCES IN THE NINETEENTH CENTURY,

WITH

Illustrative Anecdotes, Engravings & Diagrams.

EDITED BY

R. YORKE CLARKE.



THIRD EDITION.

LONDON:

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1850

TO

SAMUEL MORTON PETO, ESQ., M.P.

WHO,

AS A CONSPICUOUS AGENT IN THE VAST ENTERPRISES

WHICH FORM THE SUBJECT OF THESE PAGES,

AMIDST PREVALENT SELFISHNESS, FOLLY AND FRAUD,

SET A NOBLE EXAMPLE

OF INTEGRITY, CHRISTIAN WISDOM AND PHILANTHROPY,

THIS VOLUME IS INSCRIBED,

BY PERMISSION,

WITH THOSE SENTIMENTS OF RESPECT

WHICH ARE JUSTLY CLAIMED BY PRIVATE WORTH

AND BY HIGH AND CONSISTENT CONDUKT

IN PUBLIC LIFE,

BY HIS OBLIGED AND OBEDIENT SERVANT,

THE EDITOR.



ADVERTISEMENT.

THE three sections of which this volume consists, contain a popular description of all that appertains to intercommunication by means of the Steam-Engine, Railway, and Electric Telegraph. It is therefore evident that the subject on which the book treats, is too extensive in its details to be fully entered upon in the space to which it is necessarily confined; but there are certain grand outlines in every department of human knowledge, and great fundamental principles belonging to every science, that may be usefully explained in a work of no greater magnitude than the present. To lay down these outlines and principles as clearly, and as briefly as the nature of the subject would admit, has been the object of the Editor, and the great success of the work, as first published in sections, entitled "The Rail," "The Locomotive," and "The Electric Telegraph," would induce him to hope that to a certain extent he has succeeded. He also trusts, that if those who have been led to consider the subjects here treated of in a popular way, should feel inclined to enter more fully into their details, by seeking further information in more scientific treatises, they will find that the knowledge gained by the perusal of this little manual, will have cleared the way to profounder examination.

London, Dec. 1849.

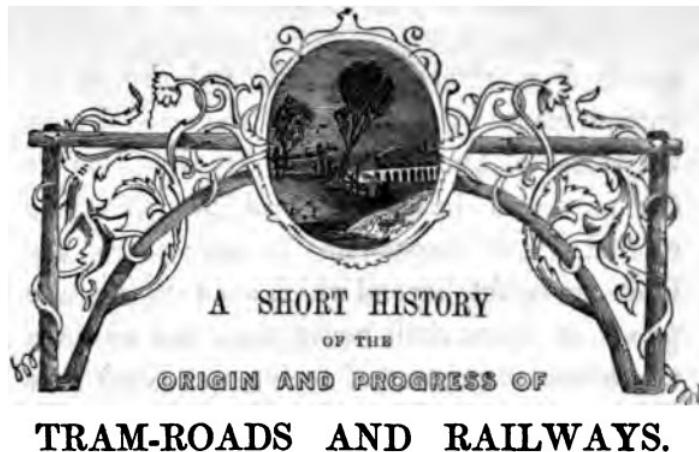


CONTENTS.

	Chapter.
Introduction	I.
Origin and Progress of Tram-roads and Railways	II.
The first Railway and its Construction	III.
Accidents, Traffic, and Expenses	IV.
Objections to Railways	V.
The "Navvies"	VI.
How to carry out a Railway	VII.
Origin and Progress of Steam Locomotion	VIII.
Locomotive Engines—Steam Boat	IX.
The Railway Locomotive Steam Engine	X.
The Atmospheric Railway	XI.
Locomotive Engines on the common roads	XII.
Origin and Progress of Telegraphic Communication	XIII.
The Electric Telegraph	XIV.

CONTENTS.

	Chapter.
Mechanical Telegraphs:--	
The Printing Telegraph - - - - -	XV.
Bains's System of Electro-Telegraphic Communication - - - - -	XVI.
Morse's Telegraph - - - - -	XVII.
Brett and Little's Electric Telegraph - - - - -	XVIII.
The Submarine Telegraph - - - - -	XIX.
The Dial Telegraph - - - - -	XX.
Phenomena, Anecdotes, etc. - - - - -	XXI.
The Electric Clock - - - - -	XXII.



A SHORT HISTORY
OF THE
ORIGIN AND PROGRESS OF
TRAM-ROADS AND RAILWAYS.

INTRODUCTION.

Soon shall thy arm, unconquered steam, afar
Drag the slow barge, or drive the rapid car.
Or on wide-waving wings expanded bear,
The flying-chariot through the fields of air.
Fair crews triumphant, leaning from above,
Shall wave their fluttering kerchiefs as they move;
Or warrior bands alarm the gaping crowd,
And armies shrink beneath the shadowy cloud.

DARWIN.



THE main object of the busy age in which we live, seems to be to shorten distance, and to save time. For this purpose, hills are levelled and vallies filled up,

ORIGIN AND PROGRESS OF

canals dug, rivers deepened, and the steam engine made in a thousand ways to supply the office of human hands. To what extent the means of locomotion will be ultimately carried it is impossible to say: there are limits, no doubt, beyond which even the gigantic power of steam shall never pass, and we have no chance at present of seeing the latter part of the poet's prophecy accomplished. Yet if we look back, through the vista of past years, to no greater distance of time than the memory of many a living man can be carried, we shall find that so great has been the progress of human science, particularly in the case of locomotion, that a sanguine man might almost be pardoned for believing that the poet's fiction may some day be accomplished.

Within seventy years the general mode of conveyance for the carrying trade to Yorkshire and Lancashire, from the West of England and Birmingham, was by the means of pack-horses, while the usual accommodation for travellers was the fly-waggon or the slow coach. Perhaps a retrospective glance at the facilities for travelling possessed by our grandfathers, will enable us the better to appreciate the

TRAM-ROADS AND RAILWAYS.

advantages or disadvantages of our present system.

It is not an easy matter to discover the time when the first stage coach started for the conveyance of passengers ; but, in 1662, it is tolerably well ascertained, there were only six in all the country, but even these six were considered by a wise man of the day, John Crossell of the Charter-House, to be six too many—he objected to them entirely, and endeavoured to write them down. It was said at the time, however, that he was merely the agent of the country gentlemen, who were afraid that if their wives could get easily and cheaply up to London, they might not settle so well afterwards to their domestic duties at home.

Referring to a more recent period, the middle of the seventeenth century, we find it recorded, that in 1742, the Oxford stage coach left London at seven o'clock in the morning, and reached Uxbridge at mid-day. It arrived at High Wycombe at five in the evening, where it rested for the night, and proceeded at the same rate for the seat of learning on the following day ; and this, be it remembered, took place on a main road near to

ORIGIN AND PROGRESS OF

the metropolis, and consequently in better order than the roads in general. About fifty years ago the Holyhead mail left London at eight at night, and arrived in Shrewsbury between ten and eleven the following night, taking twenty-seven hours to run one hundred and sixty-two miles. This distance, however, before the establishment of Railways, was done without difficulty in sixteen hours and a quarter.

At the time when this rate of travelling was considered all that was required, there was a coach on the road between Shrewsbury and Chester, called the "Shrewsbury and Chester Highflyer." This coach started from Shrewsbury at eight o'clock in the morning, and arrived at Chester at about the same time in the evening, the distance being forty miles. This was a good hard road for wheels, and rather a favourable one for draught. "But how," enquires a writer in the "Quarterly Review" for 1832, "can all these hours be accounted for? Why if a 'commercial gentleman' had a little business at Ellesmere, *there was* plenty of time for that; if a 'real gentleman' wanted to pay a morning visit on

TRAM-ROADS AND RAILWAYS.

the road, there could be no objection to that. In the pork-pie season, half-an-hour was generally consumed in consuming one of them, for Mr. Williams, the coachman, was a wonderful favourite with the farmers' wives and daughters all along the road.

“ The coach dined at Wrexham, for coaches lived well in those days ; they now live upon air ; and Wrexham church was to be seen—a fine specimen of the florid gothic, and one of the wonders of Wales ! Then Wrexham was also famous for its ale ; there were no public breweries in those days in Wales ; and above all the inn belonged to Sir Watkin. About two hours were allowed for dinner ; but ‘ Billy Williams,’ one of the best-tempered fellows on earth, as honest as Aristides, was never particular to half-an-hour or so. ‘ The coach is ready, gentlemen,’ he would say, ‘ but don’t let me disturb you if you wish for another bottle.’ ”

This was the plan adopted in the good old times, when every affair of life moved on at a quiet, jog-trot pace, not at all adapted to the present mode of carrying on business. Competition of the most eager kind has been for

ORIGIN AND PROGRESS OF

some years the order of the day, and most certainly it cannot be said that stage coaches stood still. Leaving out of the question the light coaches, which travelled at an extremely rapid rate, we may notice the speed maintained by the mails, which had to travel long distances, before their employment was superseded by Railways. The Edinburgh mail ran four hundred miles in forty hours, stoppages included. This was nearly eleven miles an hour. A coach to Exeter, the "Herald," went over its ground, one hundred and seventy-three miles, in twenty hours, and that in a very uneven country ; and the Devonport mail performed its journey, two hundred and twenty-seven miles, in twenty-two hours. This increase of speed was alarming to those who had been accustomed to the old fashioned slow coaches, and the rate at which the new vehicles travelled was considered as a reckless risking of human life. Nevertheless the thing went on, and it began to be whispered, in spite of the merciless ridicule of the "Quarterly Review," that if steam were to be employed *on a Railroad*, it would even be possible to *attain a speed of some twenty miles an hour.*

TRAM-ROADS AND RAILWAYS.

In reference to a proposed London and Woolwich Railroad, the "Quarterly" not only backed "old Father Thames against it for any sum," but assured its readers that the people of Woolwich "would as soon suffer themselves to be fired off upon one of the Congreve's *ricochet* rockets as trust themselves to the mercy of such a machine, (a high pressure engine) and going at such a rate (eighteen or twenty miles an hour!)" And the reviewer expresses his trust that "Parliament will, in all Railroads it may sanction, limit the speed to eight or nine miles an hour, which is as great as can be ventured upon with safety!!" The experiment has, however, been tried, and we all know with what success.



ORIGIN AND PROGRESS OF
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ROADS AND RAILWAYS.

The small amount of friction encountered by a wheel when it rolls over a hard surface was well known to practical mechanics, and it was found that a horse could drag a much heavier load over a hard, smooth, level road, than it could over one with a rough surface. To produce something resembling a road of this description, Tram-roads were constructed. These were almost exclusively confined to the neighbourhood of coal works and mines, and merely consisted of wooden beams laid down along the road.

To make a Railway of this description, the ground is first levelled, or rather formed so as to have a slight inclination towards the port from whence the coals or ore are shipped. Pieces of timber, about six feet long and six *inches in thickness*, are laid across the road, *at about a foot or a foot and a half distance*

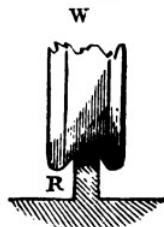
TRAM-ROADS AND RAILWAYS.

from each other. These are called *sleepers*. Upon these sleepers other pieces of wood called *rails*, four or five inches square, are laid, lengthwise of the road, and four feet distant from each other for the wheels of the waggons to run on. The advantages obtained by a rude wooden railway of this kind, with a declivity of fifty-five feet in a mile, are so great that a single horse will take down waggons containing from twelve to fifteen tons, and bring back the same waggons with four tons in them. The first wooden railway seems to have been employed at Newcastle in 1680, for transporting coals from the pits to the river Tyne, upon which duty, it is stated, even at that time, from four to five hundred carts were employed.

It was soon discovered, however, that one great disadvantage accompanied the employment of wood for the construction of the *rails*—it was liable to rot. Accordingly, instead of wooden rails, flat iron bars were employed. These were nailed to the sleepers in the same manner as the timber rails, and this change in construction was found to answer well, there being less friction to overcome on

ORIGIN AND PROGRESS OF

the iron than on the wooden rails. In other instances stone was employed in the construction of these roads, being sometimes used to form the rails, and in other cases, where iron rails were employed, the sleepers were formed of stone. An application of the railway system was made near Colebrook Dale, which is, perhaps, not generally known. Upon this railway loaded boats are drawn up to a canal, two hundred and twenty feet above the level of the river Severn, and let down into it in a similar manner, by which means twenty-two locks were saved, and the work executed in an expeditious manner. A subsequent improvement was made in the iron rails, by forming what is called an edge rail, thus—
The advantage of this consists in the fact that neither the wheel nor the rail becomes clogged with dirt as was frequently the case when flat rails were employed. The annexed figure is a section of a part of a wheel and rail. W is the wheel with a deep groove formed to receive the rail R. This form of rail was adopted about 1789, and since that time there have



TRAM-ROADS AND RAILWAYS.

been several improvements on the same principle. Dr. James Anderson in his amusing and instructive work, "Recreations in Agriculture," &c., recommended the construction of Railways for the purpose of conveying agricultural produce from one part of a farm to another. But the most interesting suggestion made by this able writer was a plan for a general extension of Railways or Tram-roads throughout the kingdom. The vehicles, of course, were to have been drawn by horses, for the locomotive engine was unknown at the time he wrote on the subject (1801). One portion of his paper is, perhaps, sufficiently curious to be worth quoting even at the present day, showing, as it does, how earnestly he had entered into the plans for carrying out his favourite scheme.

"Suppose," he observed, "a Railway were brought from the wharfs to Bishopgate-street, or any other more commodious part of the town. And supposing all the waggons to be made of one size and form, each capable of containing one ton of sugar, or other goods of similar gravity. Let the body of each of these waggons be put upon a frame that rests

ORIGIN AND PROGRESS OF

upon the two axles of four wheels, calculated to move only upon the Railway, and let each of these waggons be loaded with goods which are to go to the same warehouse or its vicinity. The whole of the waggons being thus loaded, they are moved forward till they come to the end of the road, at which place they should be made to pass under a crane. When a waggon comes under the crane (or, for the sake of expedition, a crane may be provided for each waggon,) let it be lifted up from the crane and transferred at once to another similar frame, resting on wheels, formed for going along the streets, to which is attached a pair of shafts for a horse to move in. The carter has then no more to do than to go off with his load to the street and house to which it is directed ; where, having unloaded it, he may return directly with the empty waggon, where it can be lifted from the wheels by another crane, further on than the unloading crane, and still above the Railway, on which it can remain suspended until an empty set of rail wheels shall come to receive it ; these return waggons, whether full or empty, are then lowered down on the rail wheels and taken back to the wharfs, and so on."

TRAM-ROADS AND RAILWAYS.

“ Nothing surely,” he continues, “ can be more easy, or more simple, than this arrangement ; and if the Railway were carried forward along the skirts of the town, in a direction that should be found convenient, until it reached the Paddington canal, having delivering cranes as above described at every principal street it passed, goods might thus be distributed all over the town with the utmost convenience and economy, or sent forward by canal to distant places ; and goods coming from the canal could, in like manner, be distributed to the town, or taken to the wharfs, as circumstances might require.” “ On the same plan it is certainly very practicable to carry roads of a similar description from London to Bath.” The advantages likely to result from his plan he thus notices :—“ The convenience of such roads would be very great from the circumstance of having separate moveable waggons as above stated. One separate waggon or more could be thus left at any place on the road, and others taken up in their stead, like passengers in a stage coach, without disturbing the others. Farmers, too, near these roads, could thus send their corn by that means to any distance they

ORIGIN AND PROGRESS OF

might find convenient, and get back in return manures, or goods of any sort they might want, with perfect safety ; each person having his own waggon, if he so chose it, covered and locked, so as to be opened only by those who have the key.” It is worth remarking here that the Regent’s canal was constructed for the same purpose as the projected Railway of the learned doctor, as a means of conveying goods from the docks to the Paddington canal, and that a bill was lately laid before Parliament to enable a company to fill up the canal and construct a Railway in its place. The doctor’s plans, however, were not carried out to the extent he anticipated. But coals are brought from Kilburn to Derby at the present day by canal in coal bodies of this description, and being placed on wheels they form ordinary one horse carts. Tram-roads or Railways nevertheless began to spread over the face of the country, more particularly in the northern districts of the island ; but no one contemplated their employment as a substitute for stage coaches until about the time the locomotive engine was invented. The scheme for extensive *Railways, the motive power being horses, was*

TRAM-ROADS AND RAILWAYS.

never carried into effect, although in 1830, when the London and Birmingham Railway was projected, it was in the first instance proposed to employ animal power, and the vehicles were warranted to go at the rate of eight miles an hour. Previously, however, on the 27th September 1825, a short public Railway, sanctioned by Act of Parliament, was opened, between Stockton and Darlington in the county of Durham, a distance of about eleven miles. But at an earlier period still, in 1804, a locomotive engine, patented in 1802 by Messrs. Vivian and Trevethick, was successfully applied on a Railroad at Merthyr Tydvil for the conveyance of coals.

We must not omit to notice, however, the efforts of Mr. Thomas Gray, who is still living. Like Dr. Anderson he advocated a general system of iron Railroads, and, in 1820, he published a pamphlet on the subject, containing numerous engravings, representing the proposed form of the carriages, trucks, &c. It has also been shown that Mr. Gray was the original projector of the Liverpool and Manchester line, as the preliminary experiment for a general *system of Railways throughout England.*

ORIGIN AND PROGRESS OF

At the same time he published a map of a system of direct trunk lines, which, after fifteen years experience and a large expenditure of capital, are now found to be essential parts of the present arrangements. When he first published his practical plan in 1820, it seems he was considered a visionary; and notwithstanding his persevering efforts, and the memorials he addressed to influential men, he was utterly neglected; and it was not until a pamphlet was published in 1845, written by Thomas Wilson, Esquire, of Brussels, that the present generation appeared to be aware of what he had done, for his name even appears never to have been mentioned in any work on Railways.

In comparing the merits of Gray with those of Dr. Anderson, we must consider how much the means of locomotion had improved since the day when the doctor wrote on the subject; and, therefore, we must naturally have expected that the plans of the later writer would be necessarily more comprehensive.

Before Gray published his work he placed it in Mr. Wilson's hand, and addressing him at the same time with peculiar solemnity of countenance, "Here," he said "is the main-spring

TRAM-ROADS AND RAILWAYS.

of the civilization of the world : all distances shall disappear ; people will come here from all parts of the continent without danger and without fatigue ; distances will be reduced one half ; companies will be formed ; immense capital paid and invested ; the system shall extend over all countries ; emperors, kings, and governors, will be its defenders ; and this discovery will be put on a par with that of printing." Such were the prophetic words he employed on the occasion. On the title page of his work he had written, "Observations on a Railroad for the whole of Europe."

"The project," continues Mr. Wilson, "was so great, and at the moment appeared to me to be so chimerical, that I could not help the exclamation, 'the poor man is insane !' Yet in this year, 1845, we live to see it already carried out to an immense extent ; and within five years more, supposing one half only of the projected lines to be executed, we shall have one almost uninterrupted line of railway communication from the Pillars of Hercules to the Moskwa, to say nothing of the numerous lateral and diverging lines and branches in the various

ORIGIN AND PROGRESS OF

states of continental Europe and the railway lines of Great Britain."

Across the Atlantic we have the United States with their thousands of miles of Railroad made, and one gigantic project, proposed at this moment, for the construction of a Railroad from the western shores of Lake Erie to the navigable part of the Columbia river in the Oregon territory, a distance of 2,750 miles, and which would directly connect the Atlantic shores of the Union with the great Pacific.

Cuba has its Railroad, and is trying for more. Jamaica will scarcely lag behind ; and the two isthmuses of Panama and Suez seem, at length, on the eve of being crossed with Railways, and far-off India is laying down lines for survey, resolved to draw closer the links of communication between the distant points of her extended regions.

The notice thus taken of Gray's services in the cause of Railways has excited much attention, and a number of influential men are at the present moment endeavouring to raise a fund by public subscription to recompense him for his past exertions.

THE FIRST RAILWAY, AND ITS CONSTRUCTION.

The Liverpool and Manchester was the first Railway of any magnitude that opened its line for the carriage of passengers. The first prospectus of this company was dated October 29, 1824, and the work was completed and opened to the public on Wednesday the 15th September 1830. On this occasion, as early as seven o'clock in the morning, the people of Liverpool were seen flocking in crowds to the tunnel at the commencement of the Railway, to secure good places for viewing the procession. The Duke of Wellington and other men of note were present, and the procession left Liverpool at twenty minutes before eleven o'clock, drawn by eight locomotive engines in the following order :—the Northumbrian, with the directors and numerous distinguished visitors, including the Duke of Wellington ; the Phoenix, with a green flag ; the North Star, yellow ; the Rocket, light blue ; the Dart,

ORIGIN AND PROGRESS OF

purple; the Comet, deep red; the Arrow, pink; and the Meteor, with a brown flag. The Northumbrian drew three carriages; the first containing the band, the second the Duke of Wellington and others; and the third the directors of the Railway. The Phœnix and North Star drew five carriages; the Rocket three; and the Dart, Comet, Arrow, and Meteor, each four. The number of passengers conveyed on this occasion was 772. The speed maintained was not more than from fifteen to sixteen miles an hour; but that rate was intentional, to allow the company to inspect the works as they passed along. The first trial of the undertaking was completely successful, and everything would have gone off well had it not been for a melancholy accident that happened to the distinguished statesman, Mr. Huskisson.

The accident appears to have arisen from the irresolution of the unfortunate gentleman. He was standing close to the carriage that conveyed the Duke of Wellington; for the train having stopped at Park-side Bridge, several of the passengers, against the advice of the company's servants, got out of the carriages, among

TRAM-ROADS AND RAILWAYS.

them was Mr. Huskisson. If he had stood close up to the carriage he was near, another train might have passed without injuring him ; but, unfortunately, the moment before the Rocket passed, he caught hold of the open door of the Ducal Car, which was struck by the passing engine, and being thrown on the line of rails upon which the Rocket was moving, his right leg came in contact with the wheel of the engine and was completely crushed ; so serious, indeed, were the injuries he received, that death put an end to the patient's sufferings a few hours after the accident.

The establishment of this Railway soon exhibited the advantages to be derived by employing this mode of transport ; so soon, indeed, was this manifest that eighteen months after the completion of the work it had carried 700,000 persons, being an average of 1,070 per day. Previous to the establishment of the Railway there were twenty-two regular and seven occasional coaches, which could only carry, when full, 688 persons per day : the time occupied by the coach was four hours, and by the rail one hour and a half. The

ORIGIN AND PROGRESS OF

cheaper rate at which goods and passengers could be conveyed was another advantage over the conveyance by canal or coach, and the manufacturers of Manchester alone, it is said, saved more than £20,000 per year, merely in the carriage of cotton. Before Railways were carried to any great extent heavy goods were conveyed from one end of the kingdom to the other by means of canals. The carriage was at a lower rate than when goods were sent by the road ; but slow as our “ fly waggons,” as they are or once were called in some parts of the country, used to be, they were immensely more expeditious than boats on a canal, especially where many locks had to be passed through. The passage from Liverpool to London by canal, some years back, occupying nearly a fortnight.

But there are other benefits arising from this rapid means of communication besides the convenience and cheapness of transit. The frequent communication between the inhabitants of different parts of the kingdom, is clearly a means by which the arts of civilization *may, nay must,* be more universally propagated ; the quick and cheap conveyance of

TRAM-ROADS AND RAILWAYS.

produce will induce the farmer to take more land into cultivation ; and the reduction in the poor rates, owing to the large amount paid by the railway companies, is another advantage to the inhabitants of rural districts, in addition to the increased value of land.

If, on the other hand, we look to those who dwell in our thronged cities, what benefits do we not perceive they might derive from the more frequent employment of Railways. Much has been lately done and projected to improve the sanatory condition of the people ; but too little has been thought of the great assistance that might be rendered to this cause by the agency of the Railroad. What vast numbers of our crowded population might be removed from the contaminated atmosphere, both moral and physical, of great cities, by the establishment of small villages by the side of the Railroad, within the distance of ten miles from town ! and, while the workman could be brought to his work in half-an-hour, and at an extremely low charge, his wife and family would be benefitted by the greater pureness of the *country air* and the superior cleanliness of their dwelling.

ORIGIN AND PROGRESS OF

Great, however, as the advantages of Railways are, it was not without enormous pecuniary cost, and, in many cases, fierce opposition, that they were carried into effect. We have already stated that the first prospectus of the Liverpool and Manchester Railway was issued in 1824. At the beginning of 1825, a bill was brought into Parliament to authorise the establishment of a company, but on account of the opposition it met with, chiefly from the canal proprietors, it was withdrawn. In 1826, another bill was introduced and carried ; and in June of the same year, the work was begun. A short sketch of the operations on this Railway will give the reader some notion of the difficulties that lie in the way of undertakings of this nature.

The distance between Liverpool and Manchester by Railway is about thirty-one miles, and the Docks at Liverpool are sixty-six feet below the level of Manchester; but at Edge Hill, close to Manchester, the ground is one hundred and sixty-nine feet above the Docks. Now it was necessary to render this *ground as nearly level as possible*, and this *could only be done by lowering the hill*, or

TRAM-ROADS AND RAILWAYS.

by excavating a tunnel. The latter plan was resorted to at Liverpool, at the back of which the ground suddenly rises, and to avoid interfering with the town itself, it was determined to cut a tunnel under it. This tunnel, which, in some places, was carried through solid rock, is 5,910 feet in length. Among other operations sixty-three bridges had to be built, and the cuttings amounted to about 720,000,000 cubic yards, while the embankments were 277,000 cubic yards, which, together with the tunnelling and other works, presented difficulties none but British engineers would have undertaken, and for which none but British capitalists would have risked the cost.

When the works were begun there was one peculiar natural obstacle to be overcome. The road was intended to pass over Chat Moss, a piece of boggy land, five miles and a half in width, and it was very much doubted at the time whether this road could be formed, for in some places, the bog was from thirty to thirty-five feet in depth, and so soft that an iron rod would sink through it by its own *gravity*; and yet through skill and enterprise,

ORIGIN AND PROGRESS OF

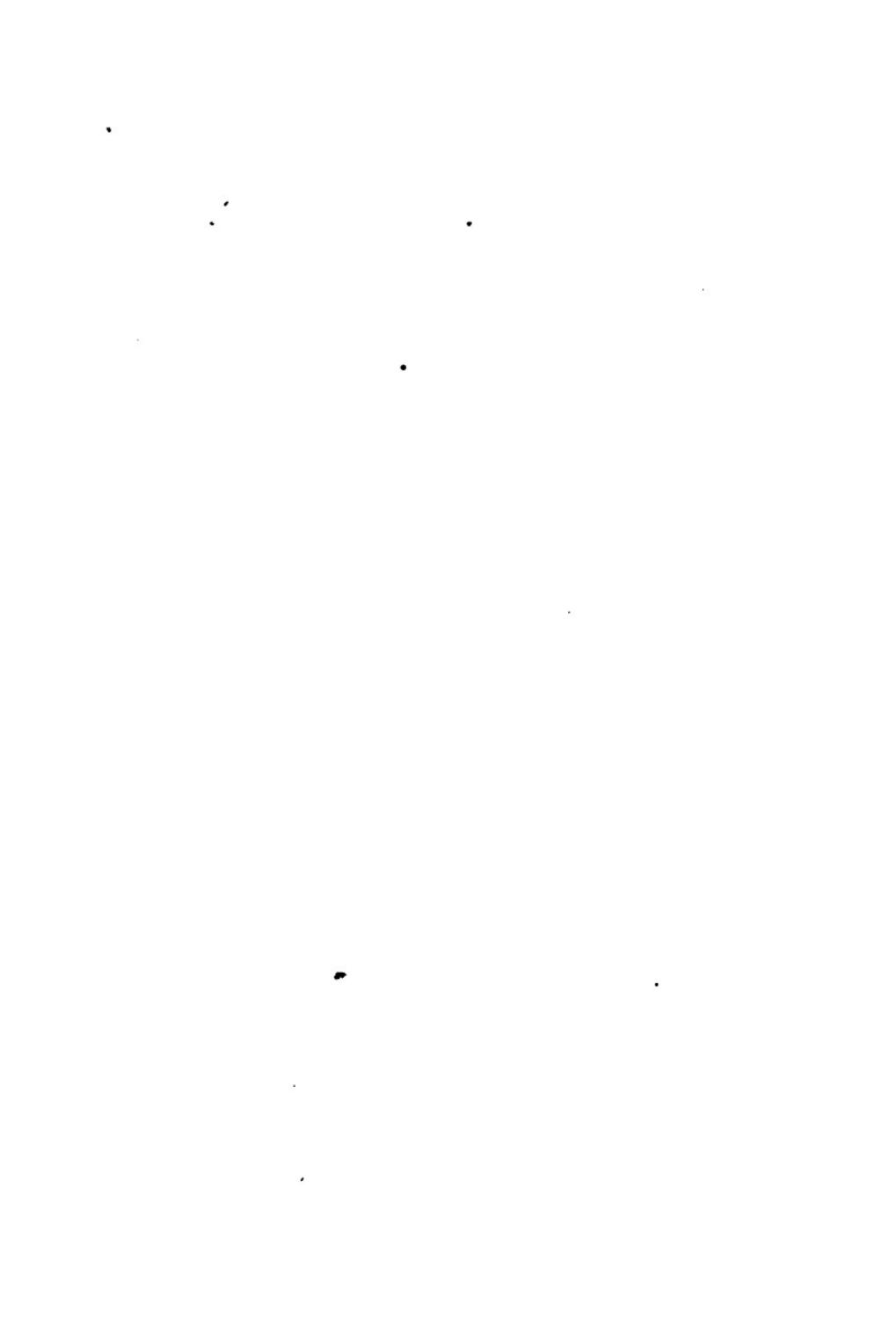
in less than three years afterwards, a locomotive engine and a heavy train of carriages passed over it. That part of the Moss which presented the greatest difficulty was about half a mile on its eastern border, where an embankment had to be formed twenty feet above the natural level. The weight of this mass of earth pressed down the original surface, and many thousand of cubic yards of earth disappeared in the half fluid bog, before anything approaching to the intended level could be obtained.

A viaduct or elevated roadway across Sankey Valley was another difficult task. For the security of the work, it was necessary to drive two hundred piles, varying from twenty to thirty feet in length, into the foundation of each of the ten piers. Thus, in all, two thousand piles had to be driven, and all those who have seen the pile driving engine at work and noticed the small progress made at each blow from the ponderous monkey, will have some idea of the labour and tedious nature of the task.

The tunnel we have already noticed, was another laborious undertaking ; it was begun



VIADUCT.



TRAM-ROADS AND RAILWAYS.

in 1827, and carried forward night and day with untiring perseverance. For the sake of greater expedition it was constructed in seven or eight different lengths, each communicating with the surface by means of shafts through which the substance excavated was drawn up.

At length, on the 9th of June 1828, it was reported to the directors that the last joining between the several lengths had been effected. To add to the difficulties of this undertaking, the excavators, on several occasions, refused to work, for in some cases there was much danger to be dreaded. At one part of the working, for instance, for want of sufficient props, a large mass of loose, moist earth and sand fell in ; the water was, in other instances, equally troublesome, if not quite as dangerous. The breadth of this tunnel is twenty-two feet, the side walls being five feet high, with a semi-circular arch of eleven feet radius, making the height sixteen feet. As before stated, it is one thousand nine hundred and seventy yards in length, and rises one hundred and twenty-three feet, on an inclination of one in forty-eight. This tunnel throughout its whole length is lighted with gas, and the sides and roof are whitewashed.

ORIGIN AND PROGRESS OF

This, however, is an exception to the general rule, and some of the tunnels on the Railways of later construction, are as dark and dismal as any lover of the horrible could wish.



ACCIDENTS, TRAFFIC, EXPENSES.

What faith must not a traveller by Railway have in the skill and care of the engineer when he trusts himself under his guidance, and is hurled along at the rate, perhaps, of forty miles an hour through one of these subterranean tunnels. When mid-way, perhaps, another train is coming in the opposite direction, and you hear the continual beating of the piston and the shrill whistle of the engine as with warning voice it tells of its approach, and then with a rush, a clank, and a crash, the two trains pass each other,—and yet so accustomed are we to these perils that nobody seems to think of the danger. After all, however, the number of accidents, in proportion to the number of passengers carried, and the number of miles travelled, was ten times as many in the case of coaches as in that of Railways. By a parliamentary return, it appears that the *number of accidents* in 1842, on all the

ORIGIN AND PROGRESS OF
Railways in England and Scotland, was as
follows :—

	Killed.	Injured.
Accidents of a public nature, attended with personal injury to the public	5	14
Accidents attended with personal injury to individuals, owing to their own in- advertence or misconduct	26	22
Accidents attended with personal injury to servants of the company, under cir- cumstances not involving public danger	42	35
	<hr/> 73	<hr/> 71

In 1844, the number of accidents reported in England, Scotland, and Ireland, were 84 killed and 102 injured; but then it is to be considered that many new lines had been opened during the two previous years, and the traffic had greatly increased. Out of the above number there were 6 passengers killed, and 40 injured ; 20 of the latter were injured on the London and Croydon Railway, in consequence of the signal light having gone out.

The following statement of the passenger *traffic for 1842*, will give some idea of the vast *number of passengers* conveyed by Railway,

TRAM-ROADS AND RAILWAYS.

and of the miles travelled. The number of passengers carried during that year amounted to 24,650,000, conveyed on the average thirteen and a half miles each. Of these, 24,068,000 travelled on the seventeen hundred and fifty miles of passenger Railways, properly so called, giving an average of 13,700 passengers per mile ; or if we leave out of the account the three short metropolitan lines, the Blackwall, Greenwich, and Croydon, upon which alone 4,030,837 of the whole 24,068,000 passengers were conveyed, (of this number the Blackwall Railway carried 2,153,723, the Greenwich Railway 1,518,587, and the London and Croydon 358,527 passengers,) it gives for the general traffic of the kingdom an average of 11,800 passengers per mile, per annum, carried on the average, fifteen miles each. The average gross receipts, per mile per year, on one thousand seven hundred and fifty miles of Railway is £2,570, of which £1,740 arose from passengers, £554 from merchandise and minerals, £98 from cattle, horses, and carriages, and £178 from parcels, mails, and other sources. The gross receipts for passengers during the year was £3,082,760 ; for merchandise and minerals,

ORIGIN AND PROGRESS OF

£1,072,313 ; cattle, horses, &c., £180,461 ; parcels, mails, &c., 306,063, making a grand total of £4,781,067. However, 1842 was a year of great depression, and there is no doubt that the money received during the last year (1846), was at least 15 or 20 per cent. more. As to the weight of merchandise and minerals, it was, in 1842, from 5,000,000 to 6,000,000 tons. The number per cent. of first class passengers was 18·4 ; second class, 46·0 ; and third class, 35·6 ; and the average rate of travelling on the principal Railways was at least twenty-four miles per hour.



OBJECTIONS TO RAILWAYS.

These few details of the amount of traffic and receipts, are clear evidence of the beneficial effects of Railways ; and yet objections of various kinds, some of them of the most frivolous nature, were put forward to obstruct their progress. Vested interests would be improperly interfered with, was the cry of a numerous body, it being forgotten that the good of the public in general ought to be the first rule by which the legislator should be guided ; the breed of horses would be destroyed ; coachmen, guards, postboys, and ostlers, were to be annihilated as a race ; and society convulsed from one extremity of the country to the other. With respect to the coach interest, what has been the consequence ? Many of the long stages have been put down, but the numerous branch coaches, omnibuses, flys, cabs, &c., &c., which have been established, show that the demand for horse vehicles and drivers has increased to an enormous extent.

ORIGIN AND PROGRESS OF

One objection of the farmers had more force ; they dreaded the introduction of so rude a class of men as the “ navvies ” into their localities ; but the evil was to be only temporary, and after all the “ navvies ” are not quite so bad as they are represented, as we shall endeavour presently to show. The country gentleman objected to his privacy being interfered with, or his land divided by the intersection of a Railway. One old lady of our acquaintance was loud in her lamentations ; she had for many years been in the habit of taking an evening stroll in a meadow near the Thames. As it happened, she herself was really a trespasser, for the land did not belong to her, neither was there a public footpath through the field ; nevertheless she considered her vested rights interfered with.

This class of objectors confined their opposition to words, or petitions to Parliament, but there was another class who took more active measures to prevent the formation of Railways —they not only opposed them in Parliament, but also in the open air, and that by physical force. These opponents endeavoured to crush the “ evil,” as they called it, in the egg ; they

TRAM-ROADS AND RAILWAYS.

knew that no Railway could be carried into effect, nor could a bill be even introduced into Parliament, until the ground over which it had to pass had been surveyed, and the levels carefully taken. Accordingly, in many instances, the surveyors were opposed by large parties of rough countrymen, and driven from the ground, with their instruments, if not their heads, broken. And eventually many of the nobility and landowners succeeded in mulcting the companies of large amounts for alleged damages. Some of these claims have been ridiculous enough. One man claimed compensation because his horses, when in the stable, were frightened by the noise of the trains and kicked each other; and a farmer in Norfolk sent in a claim because his cows would not give so much milk.

The opposition, however, was not always of this violent character. A projected line of Railway in the north of England was intended to pass through a portion of a gentleman's estate, and strict orders had been left to prevent the engineers taking the levels. The steward, *who it appears* was a pleasant fellow enough, although he determined to carry out

ORIGIN AND PROGRESS OF

the owner's intentions to the fullest extent, considered that he might do so without a personal rencontre with the men he looked upon as trespassers, he thought he might combine the *suaviter in modo* with the *fortiter in re*. He told them when they applied for leave to go over the ground, that his orders were to prevent their setting a foot upon it, and that he should use every means in his power to frustrate their plans. The engineers on their side seemed to be equally unwilling to resort to main force, and for several days, by the activity of the rich man's deputy, some object or other was placed between the surveyor's theodolite and the marked staff, erected at a distance by his assistant. In vain he shifted the instrument, the steward was on the alert, and fresh obstacles were placed in his way: in one instance, a lofty scaffolding was erected to prevent his taking a level.

Finding himself thus met at all points, the surveyor resorted to cunning to obtain his end; he called upon the steward, told him he found his case was hopeless, and that he had been ordered to abstain from all further attempts until the permission of the owner could be

TRAM-ROADS AND RAILWAYS.

obtained, which it was still hoped might be effected. In the meantime he should feel very glad to drown all animosities, if any existed, over a bottle of wine, of which he invited him to partake at the inn at which he had put up. The steward accepted the offer, and heartily tired of the trouble he had been put to, ordered the scaffolding he had erected to be removed ; and having seen this done, he proceeded to his appointment with the surveyor, whom he found in the act of locking the last of the boxes containing his apparatus. Being welcomed by the latter, he seated himself and did good justice to the liquor placed before him. At the same time, in the fullness of his heart, he congratulated himself upon the defeat of the Londoner, who on his side seemed, most unaccountably, equally satisfied, and the conversation became gradually more and more cheerful.

At length, in the midst of their mirth, a companion of the Londoner entered. He had a theodolite in his hand, and while he quietly asked his companion for the key, and replaced the instrument in the empty case, he informed his fellow Londoner that the observation he had taken proved the gradient was equal to one in

ORIGIN AND PROGRESS OF

twenty, and “that,” he observed, “completes our line, and we may bid this worthy gentleman good day, as we must be in Birmingham by the evening. I wish him better success in his next plot against a Cockney.” Even some large towns objected to the passage of a Railway in their neighbourhood. Leamington, for instance ; but soon after the opening of the London and Birmingham Railway, which had been intended to run close to their town, the inhabitants applied to Parliament to obtain a bill for a branch from the great trunk line to Leamington. A feeling of the same kind prevailed at Northampton also, and at Norwich. At the latter place, the complaint was that the Railway came too near to the city, and now the inhabitants have discovered that it is too far off.

As we have already observed, one of the great impediments in the construction of a Railway, is the enormous outlay requisite for the purpose. The expenses come under several distinct heads, and the following Table will give some idea of their amount :—

TRAM-ROADS AND RAILWAYS.

PARLIAMENTARY EXPENSES.

	Per Mile.
London and Birmingham, and	
London and South Western	£ 650 .. .
Great Western, and Manchester,	
and Leeds	1,000 .. .
London and Brighton	3,000 .. .

LAW CHARGES—ENGINEERING—

DIRECTION.

London and South Western ..	900 .. .
Grand Junction	1,200 .. .
Birmingham	1,500 .. .
Manchester and Leeds	1,600 .. .
Brighton	1,800 .. .
Great Western	2,500 .. .

LAND AND COMPENSATION.

Newcastle and Carlisle	2,200 .. .
Grand Junction	3,000 .. .
South Western	4,000 .. .
Manchester and Leeds	6,150 .. .
Birmingham and Great Western	6,300 .. .
Brighton	8,000 .. .

RAILWAY WORKS AND STATIONS.

Newcastle and Carlisle	12,000 .. .
Grand Junction	15,000 .. .
South Western	18,450 .. .
Birmingham	38,280 .. .
Great Western	40,000 .. .
Manchester and Leeds	41,400 .. .

ORIGIN AND PROGRESS OF

CARRYING ESTABLISHMENT.

	Per Mile.
Newcastle and Carlisle	1,300
Grand Junction	2,000
South Western	2,350
Birmingham and Brighton	3,000
Manchester and Leeds	3,600
Great Western	4,800

In the case of the continental Railways, the first three classes of expenses have not been so great. The "law charges," &c., on the Belgian, were £430 a mile; on the Paris and Rouen, £800. The "Land and Compensation," Paris and Rouen, £2,300; Belgian, £2,750. In "Railway Works and Stations," Belgian £10,600 per mile; Paris and Rouen, £17,000. In the "Carrying Establishments," Belgian, £2,350; and Paris and Rouen, £2,400 per mile.

If we now refer to the cost of American Railways, we find that, in 1840, there were 176 lines, intended to extend over $9,321\frac{1}{2}$ miles, of which, at that period, 3,500 miles were completed, at an average cost per mile of £4,800. The traffic upon 3,500 miles of the American Railways was, at the end of 1839, alone equivalent to 35,000 passengers carried through;

TRAM-ROADS AND RAILWAYS.

that upon 2,000 miles of English Railways equal to about 155,000 passengers carried through, and the traffic on the Belgian Railways in length 3,434 miles, equal about 260,000 passengers also carried through their whole length.

The total cost of some of the principal Railways was as follows :

Great Western (including the Branches to Exeter and Chel- tenham	£ 6,651,000
London and Birmingham	5,953,800
North Midland	3,340,000
Manchester and Leeds	3,104,000
Eastern Counties	2,737,000
London and Brighton	2,657,000
London and South Western....	2,583,700
South Eastern	2,530,000
Liverpool and Manchester	1,514,200

And the gross total of the cost of the construction of thirty-six Railways, was £54,823,700. Since this time it has been ascertained that, from the 1st of January 1826, to the 1st of January 1844, one hundred and twenty-six Railway companies obtained Acts of Parliament, enabling them to raise in the aggregate *the enormous sum of £79,026,317.*

ORIGIN AND PROGRESS OF

But during the next two years the number of projected companies for new Railways, in every part of the globe, so rapidly increased, that at length the speculation became a perfect madness, and the cause of an infinite amount of ruin and misery. Nobles and their ladies, the clergy, the bar, in addition to merchants and other speculators, rushed into the market; and the poor depositor in the savings' banks drew forth his petty hoard, and purchased shares, until at length the Legislature was obliged to interfere; but this, unfortunately, was not done until a vast amount of mischief had been effected.

The number of plans for new Railways lodged with the Board of Trade, during 1844, was 248, and during 1845, 815; but on the last day when they could be deposited, there were not less than six hundred still undelivered; and towards the last hour the utmost exertions were made to forward them. The efforts of the lithographic draughtsmen and printers in London were excessive; people remained at work night and day, snatching a hasty repose for a couple of hours upon lockers, benches, or the floor. One of the most eminent houses was obliged to bring over four hundred lithogra-

TRAM-ROADS AND RAILWAYS.

phers from Belgium, and yet even then they were unable to complete their orders. Post horses and express trains were engaged in all directions to bring plans from the country, and the greatest confusion and irregularity prevailed on the lines—in some instances the plans of rival companies being refused the requisite accommodation. Horses were engaged days before, and kept under lock and key.

At the Board of Trade, a large number of clerks were in attendance to register the deposits. The entrance hall was crowded, and all was anxiety for fear twelve o'clock should strike before the requisite formalities had been gone through. This anxiety, however, was allayed by an assurance that those who were in the hall should be entitled to have their documents received. As the clock struck twelve, the doors of the office were about to be closed, when a gentleman with the plans of one of the Surrey Railways arrived, and with the greatest difficulty succeeded in obtaining admission.

A lull of a few minutes here occurred; but just before the expiration of the next quarter of an hour, a post-chaise with reeking horses drove up in hot haste to the entrance. In a moment

ORIGIN AND PROGRESS OF

its occupants, three gentlemen, alighted and rushed down the passage towards the office door, each bearing a plan of Brobdignagian dimensions. On reaching the door and finding it closed, the countenances of all drooped; but one of them, more valorous than the rest, and prompted by the bye-standers, gave a loud pull at the bell. It was answered by the Inspector of Police on duty, who informed the ringer it was now too late, and that his plans could not be received. The agents did not wait for the conclusion of the communication, but took advantage of the doors being open and threw in their papers, which broke the passage lamp in the fall. They were thrown back into the street, and when the door was again opened, in went the plans again, but only to meet with a similar fate. As it was, six hundred plans were actually deposited. And what, the reader may ask, were the liabilities the projectors incurred for the new lines, supposing they were to be carried out? Why five hundred and sixty-six millions, nineteen thousand and six pounds sterling! and the money required to be deposited in the first instance was fifty-nine millions, one hundred and

TRAM-ROADS AND RAILWAYS.

thirty-six thousand, and three hundred pounds sterling.

Our facetious contemporary, "Punch," could not allow so favourable an opportunity for a joke to pass unnoticed. Accordingly, after describing the hair-breadth escapes of two rival agents on their journey to town by the Railway to deposit their plans at the office of the Board of Trade, and their luckless deposit in the mire, on account of the engine running off the rails, he proceeds:—

And there we stuck knee deep in mire,
We stormed, we swore, we stirred the fire ;
But there we were in our despair,
And neither seemed a fig to care,
 About us or our plans.
With hunger and with bruises faint—
'Twould raise the dander of a saint,
Much less a mortal man's !
With grim resolve we sat us down,
(For we were thirty miles from town,)
In hopeless certainty of mind—
 Even supposing we got there—
The Board of Trade shut up to find ;
 Oh how we both did swear !
When sudden on the neighbouring road,
A yellow with four posters showed :
 Ours—ours that chaise must be !
We rush upon the frightened boys,
We knock them off, and, joy of joys !
 Spring each to saddle tree.

ORIGIN AND PROGRESS OF

Ply, ply the whip, nor spare the spur,
Along the Great North Road we skirr,
 The clocks are striking ten !
'Tis thirty miles in two short hours :
But in a holy cause like ours,
 Agents are more than men !
So on we go, with plunge and bound,
Our wills are good, their wind is sound—
 We'll save our distance still.
But, ah ! despite our desperate pluck,
Three quarters past eleven has struck,
 As we gain Highgate Hill !
The leaders snort, the wheelers reel,
And past the Peacock as we wheel,
 Their breath comes short and thick ;
A fall ! the leader's wind is broke !
A cab ! a cab ! 'tis past a joke !
 "This if you do the trick."
I waved a flimsy in my hand.
On through Fleet-street, along the Strand,
 There's time the change to nick.
'Tis done—we've won, we've reached Whitehall !
But hark what sounds my ear appal !
 It is the Horse Guards' clock :
'Tis striking twelve—the hour is past :
Oh heavy fate ! sold, sold at last !
 At twelve the gates they lock !
And we are left outside the door,
The standing orders to deplore.



THE "NAVVIES."

Our account of Railways would be incomplete without noticing the men by whose labour they are constructed. We have talked of millions of pounds sterling raised for the purpose of carrying out these gigantic projects ; but of what avail would these sums be without the labour of the "Navvies?" and where will you find labourers equal to them, except in these islands ? This description of men began to form a distinct class at the time, when so much attention was paid to the extension of inland navigation at the latter end of the last century, and hence the term "Navvy." At the present day, however, they are more frequently known by the more appropriate name of Excavators.

"The original Navvy," observes a writer in the "Daily News," "has no home, and the immense demand for his services, occasioned by the rapid extension of the railway system,

ORIGIN AND PROGRESS OF

has caused the ranks of these men to be recruited from all quarters, and the peculiarities of the ‘Navvy’ have thus, to a considerable extent, been toned down to the level of ordinary labourers. The ‘Navvy’ is, from his avocation, stronger than the average of working men ; his wages are higher ; he has broken loose from local ties, or the influence of a permanent residence, and he has become one of a band similarly circumstanced with himself. The body of ‘Navvies’ are to him what relations and fellow parishioners are to other labourers—what the men of the same regiment or shipmates are to the soldier and sailor.

“ The agricultural labourer with his ten shillings a-week, affects to look down upon the ‘Navvies,’ who repay him with scorn and rude practical jokes. The raw recruit into the *Excavators*’ army is subjected to treatment of this description, in which the strong veteran is apt to forget that all are not so thoroughly hardened to excessive toil as himself. The thorough-bred ‘Navvy,’ is sure of assistance from his brethren wherever he goes—‘ a share of their supper, a share of their bed.’ The *Excavators* scorn parish relief, and seek sup-

TRAM-ROADS AND RAILWAYS.

port in sickness from benefit clubs, or the charity of their fellows. Many ‘ Navvies’ have laid by money, and not an inconsiderable number have raised themselves to be sub-contractors, though among them, as among every other class, the prudent are in the minority ; they are rude and boisterous, not depraved ; they buffet each other lustily in their cups ; they take pleasure in making supercilious boors, and townsmen stand in awe of their rude strength ; and they are jealous of the interference of the police.”

These are the kind of men by which the laborious part of the railway work is executed ; and it is calculated that for some years to come more than 200,000 men of this description will be required. Country justices do not know how to manage such rough customers, and call them ruffians and reprobates ; but the large railway contractors find it easy to keep them in order, and win their respect. The mere Excavator can earn his three-and-sixpence a-day, while the agricultural labourer can scarcely make his eighteen-pence : his occupation is as healthy and invigorating as that of an agriculturalist, and he earns as much as the in-door

ORIGIN AND PROGRESS OF

mechanic. Here, then, are elements for the philanthropist to work upon; and, by proper instruction, raise them to the level to which they would become entitled. Already much has been done in this way, but still much remains to be done; but, even in their present condition, they are very far superior to the mere labourer in agriculture.

And here we must not omit to notice the indefatigable exertions of Mr. Peto, the great railway contractor, who has endeavoured, by every means in his power, to improve the condition of the railway labourer. Schools have been established, circulating libraries formed, and the christian missionary has not thought his time misapplied in the task of instilling the truths of religion into the minds of this hitherto neglected portion of our population.



HOW TO CARRY OUT A RAILWAY.

Laborious and costly in its execution as the construction of a Railway is, the preliminary trouble, before the first sod is turned, is no trifling task. Leaving out of the question the mere bubble schemes, projected for the purpose of a gambling speculation, we will consider what has to be effected before a Railway can be fairly commenced.

These undertakings generally begin with a few individuals interested in the line of Railway proposed, when the project is honestly intended. But the great mass of original proprietors, even in the fairest scheme, are men of an adventurous and speculative turn of mind, who enter into these concerns for the mere purpose of making money. If the thing succeeds, and the shares rise to a large premium, as they often do, the original holders realize the profits at once, by selling out, and then apply their surplus capital to other projects with the same hope of gain. These people by going

ORIGIN AND PROGRESS OF

out make way for another class of proprietors, namely, those who look to their shares as a permanent investment.

In the early stages of a Railway Company, the directors are generally self-elected, and these, to be of any service to the company, ought to be men of great local interest, not simply men of title or of wealth—men, in fact, of business-like habits and conciliatory dispositions, and capable of reasoning down the opposition of the landed proprietors through whose property the line is intended to run.

The secretary is a very important personage ; he should be able to endure much hard work in travelling ; be possessed of much general information ; be somewhat of an engineer ; and he would be better fitted for his situation also if he were a draughtsman. Next comes the engineer, and, of course, he can be best judged by the works he has already executed.

When the Railway is decided on, and these officers appointed, the first thing to be done is to ascertain the traffic between the two places intended to be connected with each other. *This is a task that requires great care and attention.* A man must be stationed by day, and

TRAM-ROADS AND RAILWAYS.

another by night, for two or three weeks, to count all vehicles passing a given number of spots along the intended line, (these spots should be near the principal towns,) leaving out the largest terminus, as, for instance, London, and keeping the men on that side of the respective towns which is nearest the largest terminus. The number of passengers should also be noted, and the cause of any increase or decrease on particular days. The information thus obtained is entered in a book, methodically arranged, and from this book the expected traffic is calculated.

In the meantime the surveyor or engineer has been busy taking the levels of the country, boring to discover the nature of the strata he may have to cut through, and preparing a rough sketch of the ground. The engineer generally has two or three lines roughly surveyed, and from these that which seems best adapted for his purpose is selected.

Matters being thus far proceeded with, an act of incorporation must be obtained from Parliament; and now the parliamentary agent is *called in* to see that the rules of the House are properly attended to. We suppose the bill

ORIGIN AND PROGRESS OF

has escaped clear through this ordeal, and a fiery ordeal it is, and ought to purify whatever is subjected to it, it is now turned out in the form of a sterling respectable Act of Parliament, the directors have full powers, and this the holders of scrip soon discover, when the respective calls are made upon them.

The engineer has by this time made his estimates; so much for tunnelling, so much for embankments, for bridges, viaducts, &c. The principal works are done by contract. One man, for instance, will contract to form the entire line, buying the land and delivering the Railroad complete to the company; or one man may undertake an embankment; another a tunnel. These will be let out in smaller portions to sub-contractors, who, perhaps, again do the same. Thus the work proceeds until at length bridges, tunnels, viaducts, stations, termini, are all complete, and the whole staff of the company is filled up, clerks appointed, a police regulated, the locomotive placed on its destined rail, the carriages linked to the engine, and to each other, the steam up, *whizzing and snorting like an eager steed,* *the bell rings,* the whistle gives the signal



EMBANKMENT.

TRAM-ROADS AND RAILWAYS.

for departure, and off they go. The Railroad is now open ; and the vast amount of money that has been buried in it, begins slowly to return into the pockets of the shareholders.

In order, however, that all these operations may be carried on without danger, signals have been arranged, which, although they may appear strange and complicated to the passing traveller—confused, perhaps, by the rushing of the engine, the shriek of the whistle, the waving of flags, and the flashing of many coloured lamps—are, nevertheless, so simple that a mere child can understand them.

The following are the regulations and signals employed on the London and North Western Railway :—

By NIGHT—The *white light* denotes that all is right ; the *green light* that a necessity exists to proceed cautiously ; the *red light*, always, to stop.

By DAY—Flags, or boards, of the same colour, are used instead of lamps.

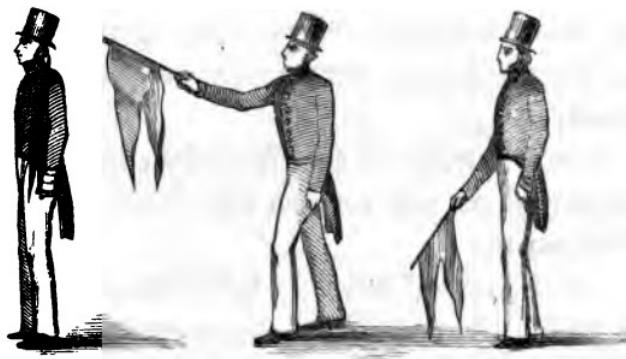
The whistle, whether by night or day, denotes the approach of a train.

A second lower tail lamp, or a red board

ORIGIN AND PROGRESS OF

attached to the end of a train, denotes that a special train is about to follow.

POLICE SIGNALS—"In order," say the standing orders of the Railway just mentioned, "to simplify the signals shown by the police, and to make them as clear and distinct as possible to the engine drivers, guards, and others, the following positions of the men and the use of the flags will be observed—



1

2

3

"When the line is clear, and nothing to impede the progress of an engine, the policemen *on duty* will stand erect with his flag in his hand, but showing no signal (fig. 1).

TRAM-ROADS AND RAILWAYS.

“ If it be required that the engine should slacken speed, and proceed with caution from another engine having passed on the line within five minutes, the green flag will be shown elevated as in fig. 2.

“ If it be required that the engine should slacken speed, and proceed with caution on account of any defect in the rails, the green flag will be depressed, as in fig. 3.

“ If it be required that the engine should stop altogether at any given point, the red flag will be shown, and waved backwards and forwards by the policeman facing the coming engine: the engine drivers will, therefore, invariably stop on coming to a red signal. Any signal, however, either by day or night violently waved denotes danger and a necessity for stopping.”

On the Midland, Eastern Counties, Norfolk, and several other Railways, the patent “ Semaphore ” is used. It consists of a tall white post, so placed as to be visible at a considerable distance. At the top are two moveable arms which fold into a case; and on each side, lamps which turn on upright axles, and can be made to show a white, green, or red light.

ORIGIN AND PROGRESS OF



4

5

6

When the line is clear, the arm is left in its case, giving the same signal as a white light, and is unseen, as in fig. 4; if half raised, as in fig. 5, it corresponds to a green light, and indicates caution; if raised to a right angle, as in fig. 6, it, like a red light, warns the driver to stop. The right hand arm gives signals for the right line of rails, and *vice versa*.

For the comfort of nervous travellers, it may be as well to say that a red light or flag does not always denote *danger*. If a train is required to stop at any place, the red signal is shown; and at stations the red "Semaphore" arm is kept up five minutes after a train has *passed*; then half lowered five minutes more; then shut up.

TRAM-ROADS AND RAILWAYS.

During a fog extra precautions are necessarily employed: for instance, the whistle is frequently blown, and detonating balls of considerable size, and making a loud report, are laid upon the rail at some distance from any serious obstacle, the wheel of the approaching engine causing them to explode as it passes over them.

Such are a few only of the precautionary measures and regulations of a Railway; but these are sufficient to enable the reader to understand to what extent his safety has been studied by the managers of these giant establishments.

We have already noticed how small the proportion of accidents is to the number of passengers carried, and the number of miles travelled by rail, but this degree of increased safety, when compared with the number of accidents that formerly occurred when the fast coaches were on the road, has only been obtained by constant attention and care: the Government itself has appointed an engineer to survey and report upon the safety of the line before it is allowed to be opened to the public. A code of signals has also been ar-

ORIGIN, PROGRESS, ETC.

ranged, which we explained in another page, and great attention is paid to the means by which the engine can cross, or be placed on, another line of rails without danger. This is effected by means of a bar of iron, called a switch, moving upon a hinge upon one side of the line of rails, and capable of being laid either into the main line, or line of sidings. These switches are moved in various ways, and are attended by a set of men called *switchmen*, or at times *pointmen*, who, by means of a lever and some other mechanical contrivance, move the switch whenever necessary.

The rail is also constantly looked after by the *platelayers*, who examine the rails morning and night, and guage its width, to ascertain it has not been disturbed by the passage of the train; and, if any damage has been done, see to its repair in due time. Over these men is placed the *ganger*, or foreman, who is responsible for the acts of those under him.







A CUTTING.



THE
S T E A M E N G I N E.

ORIGIN AND PROGRESS OF STEAM LO-
COMOTION.

Steady and swift the self-moved chariot went,—
Their way was through the admantine rock.

..... on either side
Its massive walls arose, and overhead
Arched the long passage.

SOUTHEY.



ITTLE time, comparatively, has passed since the day when a knowledge of scientific subjects was considered as not only unnecessary to the generality of *mankind*, but absolutely injurious to their

ORIGIN AND PROGRESS OF

prospects in life. The farmer laughed at the idea that chemistry could assist him in the cultivation of his land : “ the scientific gentleman who lectured at the Town Hall, may be very clever in his way, but how can he know anything about the growing of turnips or corn—what experience has he ever had ? and what the better should I be if I possessed all his learning ? ” Happily, however, the times have changed ; and the farmer, changing with them, has altered his opinion on the subject. “ My boy,” a London tradesman would have said irr those days, “ is to follow my business ; to learn to buy in the best market, and sell for the handsomest profit. What is the use of geometry, or optics, or astronomy, or heaven knows what, to him ? No : teach him to read, and write, and cast accounts, and that is all the knowledge he requires. It was sufficient for me, and it must do for him.”

The World, notwithstanding this prevailing opinion, began at last to think ; indeed it could not do otherwise, for it was no longer in leading strings ; and if it did not think for itself, *heaven help it* ; and the more the growing-up *World thought*, the more it discovered an inti-

THE STEAM ENGINE.

mate connection between every branch of human knowledge, and that these branches were not so many distinct and isolated subjects, but that they depended on each other, and merely formed portions of one comprehensive whole; and the World found out at last, that science, art, and manufactures, were more closely connected than it imagined. Perhaps this view of the case cannot be better illustrated than by describing the origin and progress of the Steam Engine, and showing how at every step of the advance it made, it called to its aid some branch of scientific knowledge, apparently unconnected with it, but in reality essential to its improvement.

That water could be converted into a vapour called steam, is a fact which must have been known from the time fire itself was first discovered, and it is not unlikely the mechanical power of confined steam may have been frequently observed long before it was ever thought of applying this force to any useful purpose. The first account we have of the application of steam, to any but culinary purposes, dates as far back as one hundred and twenty years before the christian era. Hero,

ORIGIN AND PROGRESS OF

commonly called the *elder*, a celebrated mathematician of Alexandria, during the reign of Ptolemy Philadelphus, invented a simple rotatory machine, the moving power of which was steam; and it is a singular fact that even at the present day several rotatory steam engines have been patented, the principle of which is precisely the same as that of Hero's. We know that when a bullet is driven out of the barrel of a musket by the gases into which the gunpowder has been converted, a recoil shock is felt, strong or weak, in proportion to the violence of the explosion; so again a power dependent on the same principle, launches the rocket into the air, or whirls round the firework called a "Catherine Wheel."

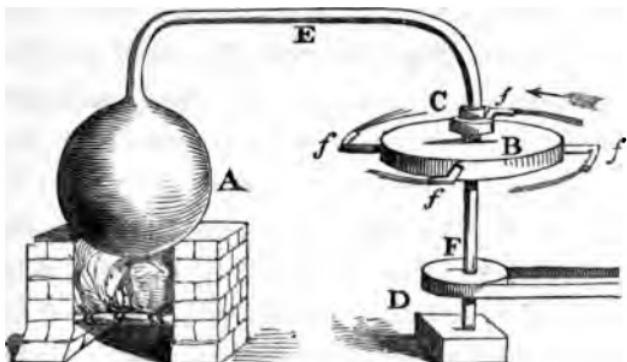


FIG. 1.—HERO'S ENGINE.

THE STEAM ENGINE.

Fig. 1 will explain in what manner this principle could be carried out by the employment of steam. Let A be a close boiler containing water; this being converted into steam by the heat of the fire placed beneath it, the steam thus formed rushes through the tube E, and fills the flat circular vessel B, which is made in such a manner as to be capable of revolving upon the pivot D, and in the steam tight socket at C. The steam having filled this vessel, is forced through the bent tubes f, f, f, &c., which are connected with its interior, and the consequence is a recoil is produced, by which the vessel would be whirled round in the direction of the arrow, as long as the boiler A can supply it with steam; but if a pulley had been placed at R, with a strap communicating with machinery, the pulley would be turned round, and the machinery set in motion with a force greater or less, in proportion to the rapidity with which the steam is forced through the bent tubes.

By this invention of Hero, it was shown that water converted into steam, filled a much larger space than the water itself, and had gained, as we see, a mechanical power, by means of which

ORIGIN AND PROGRESS OF

it was capable of producing motion in a piece of machinery. Here, however, we must pause for an instant, and examine the other properties of steam, before we can thoroughly understand the mode in which it acts in the Steam Engine.

We have already seen the effects of water when converted into steam in a vessel from which it could escape ; but if the boiler A, for instance, instead of being connected with the pipe E, had been firmly closed on every side,—what would have been the consequence ? That part of the interior of the boiler which lies above the water would have been soon filled with steam at the heat of boiling water, and this steam would press in every direction upon the interior of the boiler, with a pressure equal to nearly 15lbs. to the square inch. The fire, in the meantime, continuing to impart fresh heat to the water ; but as it is the property of water, when in a liquid state, never to rise above the boiling heat, it gives up the heat thus imparted to it to the confined steam, which gradually becomes more and more heated, but at the same time the elastic force, *with which it presses again the sides of the*

THE STEAM ENGINE.

vessel, also becomes increased, and that in the following ratio :—

PRESSURE OF STEAM.

At 212° Farenheit's Thermometer	15 lb.
250° "	30 "
275° "	45 "
293° "	60 "
510° "	750 "

Here, then, we have a vast power at our command, if we only knew how to control and economise it.

Enormous as the elastic power of steam is seen to be, there is, nevertheless, a means of increasing that power to an almost unlimited extent, by taking advantage of a law by which all fluids and gases are governed. Unlike solids, which acting simply as weights, merely press in one direction, that is, downwards towards the earth, so that a pound weight can only produce a pressure equal to a pound. Fluids, vapours, and gases, however, acting either by their weight or elasticity, transmit the power in every direction, and consequently increase its effect

ORIGIN AND PROGRESS OF

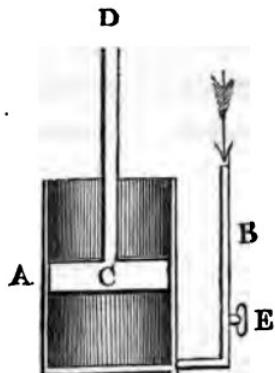


FIG. 2.

Let A, fig. 2, represent the section of a cylindrical box, in which a piston, c, can be moved upwards and downwards, but so nicely fitted in the cylinder as not to allow of the passage of steam between its circumference and the sides of the box. B is a tube communicating with a boiler in which steam is generated, say at the temperature of boiling water, 212° Farenheit. The bore of this tube is equal to one square inch, and, consequently, the elastic power of the steam presses downward in the direction of the arrow, with a force equal to 15lbs ; but as steam is governed, as we have already said, by the same law as

THE STEAM ENGINE.

fluids, it presses in every direction with the same force, and necessarily against the bottom and sides of the cylinder, and the under part of the piston. Now if the area of the under surface of the piston is equal to 50 square inches, the pressure of the steam against it would be equal to 50 times 15lb, or 750lb., and, consequently, it would be able to raise a weight equal to 750lb, placed on the top of the piston rod at D, or to impart a force equal to 750lb to a lever placed at D. Here we have an elastic force of great power, and easily increased.

We have seen how easy it is to impart this elastic force to steam, by merely heating it in a close vessel; but this vapour of water has also another most admirable property: it can, by the application of cold, be almost instantaneously reduced into the state of water again. Let us consider what is the advantage of this property in practice. For the purpose of illustrating a few of the principles of the Steam Engine, we must still refer to fig. 2. We will suppose the steam to have been introduced below the piston C, and to have raised it, so as to have lifted a weight at D, or moved a

ORIGIN AND PROGRESS OF

piece of machinery placed at the same spot. The return of the steam to the boiler can be prevented by turning the stopcock, e ; but this, it is evident, is not sufficient for our purpose, for how are we to get the piston down again? It cannot be accomplished so long as the elastic steam remains pressing against its under surface; but if this steam is suddenly cooled by means we shall presently describe, the water into which it is converted, will occupy a space about 1800 times less than the steam itself did at the heat of boiling water, a vacuum will be formed in the lower part of the cylinder, the piston will be forced down by the pressure of the atmosphere and its own weight, and thus another movement would be imparted to the machinery attached to the piston rod.

The first person who appears to have discovered this rapid method of obtaining a vacuum was Denis Papin, a learned French physician, who flourished at the end of the seventeenth century. It was about the same time also introduced to notice in a more perfect form by Captain Thomas Savary, who, in 1698, obtained a patent for a Steam Engine to raise

THE STEAM ENGINE.

water. He gives the following account of his discovery :—Having drank a flask of Florence at a tavern, he flung the empty flask on the fire, and called for a basin of water to wash his hands. A small quantity of the wine that remained in the flask began to boil, and steam issued from its mouth ; it occurred to him to try what effect would be produced by inverting the flask and plunging its mouth into cold water. Putting on a thick glove to defend his hand from the heat, he seized the flask, and the moment he plunged its mouth in the water, the liquid rushed into the flask and filled it.

Before this time water had been raised out of mines and other places by the usual laborious method of a piston and sucker, and he imagined that by first filling the barrel of a pump with steam, and then producing a vacuum, by condensing the steam, that the atmospheric air would force the water from the well into the pump barrel, and into any vessel connected with it, provided that vessel were not more than thirty-four feet above the level of the water in the well. He perceived also, that, having lifted water to that height, he might use *the elastic force of steam at a high temperature*

ORIGIN AND PROGRESS OF

to raise the same water to a higher elevation, and that the same steam that accomplished this mechanical effect, would serve by its subsequent condensation to reproduce the vacuum, and draw up more water. "It was on this principle," says Dr. Lardner, "that Savery constructed the first engine in which steam was brought into practical operation."

We have spoken of the atmospheric pressure acting upon the upper surface of the piston, and pressing it down when a vacuum is created at the bottom of the cylinder. This is the power improperly called "suction," and it has been found that a column of atmospheric air of the area of one inch square, will counterbalance a similar column of water thirty-four

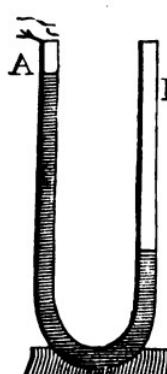


FIG. 3.

feet in height, and weighing 15lbs. It is, therefore, evident, that the atmosphere presses upon all bodies at the surface of the earth with a force equal to 15lbs. to the square inch. To render this natural fact visible to the eye, take a bent glass tube, fig. 3, place the open ends upwards, and fill the tube with

THE STEAM ENGINE.

water ; then place your thumb upon the end A, and pour out a considerable portion of the water from the other leg, you will then see that the water in the leg A will not fall to the level of that in the other leg, nor would it descend in the least, so long as the column of water in it did not exceed thirty-four feet in height ; and this arises from the atmosphere pressing on the surface of the water in the leg B, and preventing it assuming a surface level with that in A, or rather the water is unable to descend in A, against the resistance of the atmosphere in B ; but if the thumb be removed from it, then the pressure is equal on both surfaces of the water, and it rests at the same level in both the legs. That the atmosphere possesses weight can also be proved in another manner. Take a Florence flask, and having fitted a stopcock to its mouth, let the whole be accurately weighed. The air is then to be exhausted by means of an air pump, and small as the quantity was, there will, nevertheless, be a perceptible difference in the weight of the flask, when it is removed from the air pump and again placed in the scale. The pressure of the atmosphere must, therefore, be considerable, when we consider

ORIGIN AND PROGRESS OF

that it extends, perhaps, some thirty miles above the surface of the earth.

Thus we see the expansive power of steam at different temperatures; the production of a vacuum by its rapid condensation; and the pressure of the atmosphere, are the three elements with which the inventors and improvers of the Steam Engine have had to work, by adapting these powers to various mechanical contrivances.

These principles being understood, we shall continue to trace the progress of the application of steam. In the sixteenth century, the little instrument, shown in fig. 4,

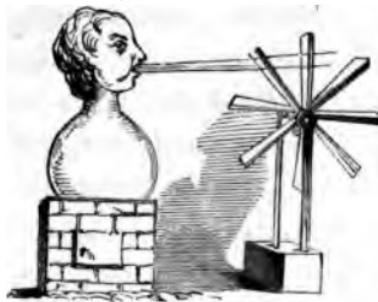


FIG. 4.

was invented. It is another application of the power of steam for the purpose of turning a

THE STEAM ENGINE

wheel by means of a current of vapour issuing from a tube fixed in a hollow ball, partly filled with water and placed over a fire. An instrument or toy similar to this is mentioned in Plot's "Staffordshire." He says, " Yet there are many old customs in use within memory, of whose originals I could find no tolerable account, such as the service due from the lord of Essington in this county to the lord of Hilton, about a mile distant, namely, that the lord of the manor of Essington shall bring a goose every new year's day, and drive it round the fire at the Hall at Hilton, at least three times (which he is bound to do as mean lord) whilst *Jack of Hilton* is blowing the fire. Now Jack of Hilton is a little hollow image of brass, about twelve inches high, kneeling upon his left knee and holding his right hand upon his head having a little hole in the place of the mouth about the bigness of a great pin's head, and another in the back about two-thirds of an inch diameter, at which last hole it is filled with water, of which it holds about four pints and a quarter. This, when set to a strong fire, evaporates after the same manner as an æolipile, and vents itself at the smaller hole at the mouth

ORIGIN AND PROGRESS OF

in a constant blast, blowing the fire so strongly that it is very audible, and makes a sensible impression in that part of the fire where the blast lights, as I found by experience.—May 26, 1680."

We may, perhaps, be allowed to advert to an employment of steam as a means of deception, if it were only by way of contrast to the present more useful application of the same agent. We are informed that on the banks of the Weser, the god of the ancient Teutones sometimes showed himself unpropitious by a sort of thunder-clap, immediately succeeded by a cloud which filled the sacred enclosure. The statue of the god Busterich discovered, it is said, in excavating, pointed out the method by which the pretended miracle was effected.

The god was of metal; the head was hollow, and contained an amphora (about nine gallons) of water; wooden plugs closed up both the mouth and another opening about the forehead; live coals dexterously placed in a cavity of the skull, gradually heated the liquid. Soon, however, the steam generated by the heat, forced out the plugs with a loud report; it then escaped with violence in two streams, and

THE STEAM ENGINE.

raised a thick cloud between the deity and his stupified worshippers. It would appear that in the middle ages some monks found their account in this invention, and that the head of Busterich has performed its office before other than Teutonic multitudes.

The most remarkable name among the earlier inventors, or supposed inventors, of the Steam Engine, was the Marquis of Worcester, who wrote a work called "The Scantling of a Hundred Inventions." The marquis having taken part with the Royalists against the parliamentary army, was obliged to seek refuge in Ireland on the failure of the royal cause. There he was imprisoned, but escaped to France. From thence, however, he again returned to England, and being again taken prisoner, he was committed to the Tower, where he remained until the restoration of Charles the Second. The story told of the cause that induced him to attempt the application of steam power to mechanical purposes, is as follows:—That, while in prison, he observed that the lid of the pot in which his dinner was cooked was suddenly raised by the *vapour of the boiling water*: he afterwards, it

ORIGIN AND PROGRESS OF

is said, remembering this incident, considered whether he might not be able to apply the same power to some useful purpose. The paragraph on which his advocates rely as establishing his claim to priority of invention, is contained in the "Sixty-eighth Invention," and is thus worded:—

"I have invented an admirable and forcible way to drive up water by fire; not by drawing or sucking it upwards, for that must be, as the philosopher terms it, *infra sphærum activitatis*, which is but at such a distance. But this way hath no bounder if the vessels be strong enough. For I have taken a piece of whole cannon, whereof the end was burst, and filled it three-quarters full of water, stopping and screwing up the broken end, as also the touch-hole, and making a constant fire under it, within twenty-four hours it burst, and made a great crack. So that having a way to make my vessels so that they are strengthened, by the force within them, and the one to fill after the other, I have seen the water run in a constant stream forty feet high. One vessel of water *rarified by fire*, driveth up forty of cold water, *and a man that tends the work has but to turn*

THE STEAM ENGINE.

two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively; the fire being tended and kept constant; which the self-same person may likewise abundantly perform, in the interim between the necessity of turning the same cocks."

This experiment was made, it is supposed, in the year 1663, and Dr. Lardner observes, that the account is "sufficiently distinct and explicit to enable any one possessing a knowledge of the mechanical properties of steam to perceive the general nature of the machine described."

It seems that after the death of the marquis, the marchioness endeavoured to carry out the project, but she was soundly rated for her presumption by a Romish Priest, who visited her for the express purpose of preventing her from proceeding. "Now, madam," he observed, "how improper such undertakings are for your ladyship, and how impossible for you to effect them, or any of them, all your friends can tell you, if they please to discover the truth to you. The effects," he continued, "*are many, as the danger of losing your health*

ORIGIN AND PROGRESS OF

and judgment, by such violent application of your fancies, in such high designs and ambitious desires; the probability of offending Almighty God, and prejudicing your own soul thereby." Nay, the confessor went further than this in his remonstrances, and attributed the lady's conduct to the deeply-laid plots of his Satanic majesty himself. These remonstrances appear to have had the desired effect, and the construction of the *great machine* was never perfected.

About the middle of the seventeenth century, 1651, an anonymous pamphlet was published, of which it has been suspected the Marquis of Worcester was the author. Be that as it may, it most singularly foreshadows the uses to which steam has been applied in later times. The author observes, after acknowledging that although he had sought in vain after the "perpetual motion, and the lessening the distance between strength and time," "yet I have advanced so near to it that already I can, with the strength or help of four men, do any work which is done in England, whether by wind, water, or horses, as the *grinding* of wheat or rape, and the raising of

THE STEAM ENGINE.

water; not by any power or wisdom of my own, but by God's assistance, and (I humbly hope, after a sort,) immediate direction. I have been guided in that search to tread in another path than ever any other man that I can hear or read of did tread before me; yet with so good success, that I have already erected one *little engine*, or *great model*, at Lambeth, able to give sufficient demonstration to either artist or other person that my invention is useful and beneficial (let others say upon proof how much more) as any other way of working hitherto known or used."

He then enumerates the multitude of uses to which his invention could be applied, and among others he states, "to draw or hale ships, boats, &c., up rivers against the stream; to draw carts, waggons, &c., as fast without cattle as with; to draw the plough without cattle, &c." "The uses," as he observes, "to which it can be applied, being very difficult, if not impossible, to name at the same time."

Ingenious as many of these ideas were, no real benefit appears to have arisen from their *application*. At length, thirty years after the

ORIGIN AND PROGRESS OF

death of the Marquis of Worcester, the first really practicably useful engine was invented, as we have already said. In Savery's engine there was no piston or cylinder. It contained two boilers, the larger called the cistern, supplying the smaller, or steam boiler, while the latter fed the working part of the apparatus with steam. Fig. 5 is a sketch of so much of the working apparatus as will enable the reader

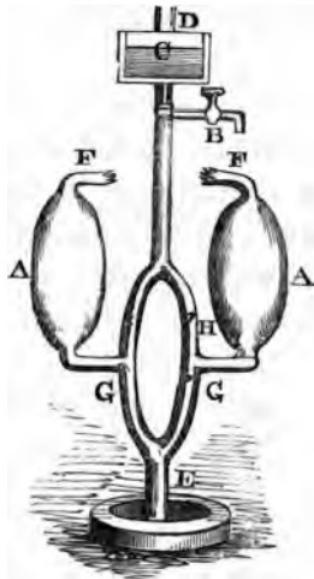


FIG. 5.

THE STEAM ENGINE.

to understand the mode of action, but it is impossible in this short account to enter into detail.

Fig. 5: A, A, are two iron vessels which are filled with steam from the boiler: B is called the condensing cock, and is in connection with the cistern of cold water C: the arm to which this cock is attached is moveable, so that the cock can be brought over either of the iron vessels, which by means of a series of valves are enabled to act independently of each other: E is the pipe through which the water is raised from the well or mine; and D, the opposite end of the same pipe, by which the water when raised is discharged. Supposing either of the vessels A to be filled with steam, the communication of the supply pipe F is cut off by means of a stop-cock, and a stream of water from the condensing cock condenses the steam in A, a vacuum is created, and the atmospheric pressure on the surface of the water in the well raises it to a certain height in the pipe E. A repetition of the process of procuring a vacuum will at length cause the water nearly to fill the vessel A, and as the steam is again admitted, it presses on the surface of the water

ORIGIN AND PROGRESS OF

in A, but it cannot drive it back down the pipe E, for a valve at G, opening upwards, prevents its return; the pressure of the steam, therefore, forces the water up the pipe D, where its return is prevented by another valve at H; a vacuum is again formed in A; again the pressure of the atmosphere drives another portion of the water up the pipe E; A is again filled; and its contents once more forced up the discharge pipe C. It is to be observed that the same thing is taking place in both the vessels A at the same time, for they act independently of each other.

In this description of engine, it is evident the three modes in which steam engines work are resorted to. It is a condensing, or low pressure, engine, inasmuch as a vacuum is created by condensing the steam: it is an atmospheric engine, for the pressure of the atmosphere is resorted to as an agent; and it is a high pressure, or more properly, non-condensing engine, since the elasticity of steam is called into play. The chief objection to Savery's engine was the great amount of power and heat uselessly expended.

The necessity for a machine of this descrip-
24

THE STEAM ENGINE.

tion, naturally caused an endeavour to be made to overcome the difficulty. A native of Dartmouth, in Devonshire, was the first to effect this improvement. His object was still, however, merely the draining of mines, which he proposed to effect by means of an ordinary pump to be worked by steam power. Instead of employing steam at a great heat and high pressure, he proposed to move a piston in a cylinder by raising it by the elastic force of steam, and depressing it by the pressure of the atmosphere. This engine was, consequently, called an "atmospheric engine."

Fig. 6 will illustrate the principles of the atmospheric engine: A is the pump rod, which is attached by a chain to one end of a working beam at B; the beam moves upon a centre at C. The other end of the beam is attached to the end of the solid rod, D, of a piston, working in the cylinder E. Now if a vacuum be created below the piston, it will be forced down, as we have already shown, by the pressure of the atmosphere, with a force amounting to 15lbs. to the square inch, and the piston of the *pump rod* would be drawn up the barrel of the pump: the steam, being again allowed

ORIGIN AND PROGRESS OF

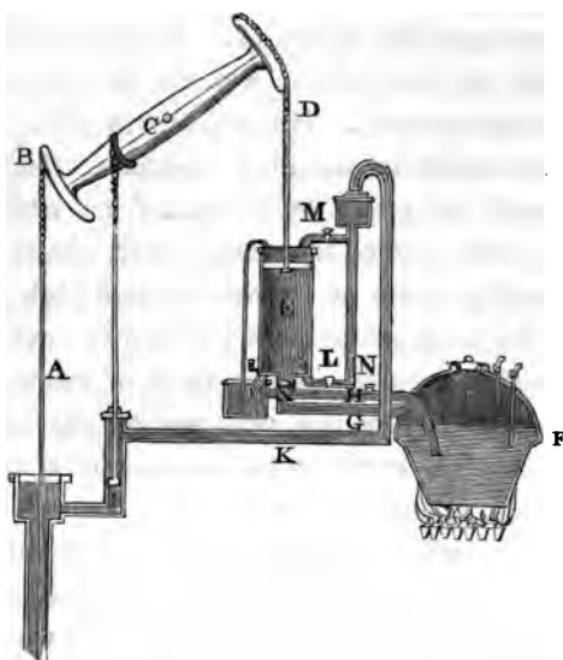


FIG. 6.

to enter beneath the solid piston in the cylinder, would press upwards with the same force, and the piston would be raised, and the pump rod would descend, in the pump barrel, and by this alternate motion, the action of pumping water would be maintained.

In fig. 6, F is the boiler; G the pipe by which the steam is conducted into the cylinder;

THE STEAM ENGINE.

h a supply pipe, connected with a cistern of water to supply the boiler. To effect the condensation of the steam, the cylinder was placed in an outer case, into which, whenever it was necessary, the pump i pumped water through the bent tube k; and as soon as the condensation was effected, the water was drawn off. But the inventor soon discovered a great improvement in the mode of condensing the steam. A jet of cold water was introduced into the cylinder by the pipe l, and it was found to produce the desired effect much more rapidly. This plan with some modifications is still in use.

In order to keep this engine in work, one man was required to attend to the fire, and another, or a boy, to turn alternately the two cocks, m and n,—n admitting or cutting off the supply of steam to the cylinder; and m allowing the condensing water to enter when necessary. The boys who performed this operation had, it is clear, a very monotonous duty to perform; and it is related that one of these, named Humphrey Potter, an ingenious lad, was tempted by a strong desire to escape from *his drudgery*, and to effect which he en-

ORIGIN AND PROGRESS OF

deavoured to discover some contrivance by which he might gratify his wishes. "On observing the alternate ascending and descending motion of the beam above his head, and considering it in reference to the labour of his own hands, in alternately raising and lowering the levers which governed the cocks, (these levers are not shown in fig. 6,) he soon perceived a relation which served as a clue to a simple contrivance by which the Steam Engine, for the first time, became an automaton. When the beam arrived at the top of its play, it was necessary to open the steam valve at *N*, by raising a lever, and to close the injection valve at *M* by raising another. This he saw could be accomplished by attaching strings of proper length to these levers, and tying them to some part of the beam. The levers required to be moved in an opposite direction when the beam attained the lowest point of its play. This he also saw could be accomplished by strings, either connected with the outer arm of the beam, or conducted over rods or pulleys. In short, he contrived means of so connecting the levers which governed the two cocks, as to turn them with the most perfect regularity

THE STEAM ENGINE.

and certainty as the beam moved upward and downward. This was a great improvement in the engine, and nothing now was needed, excepting, by occasionally turning a cock in the pipe H, to supply the boiler with water.

The atmospheric engine continued much the same in principle for nearly half a century, although the mechanism of the machinery was much improved. At length, in 1736, James Watt was born at Greenock in Scotland, on the nineteenth day of January. He was but a sickly child, but even in his childhood he gave evidence of his future greatness. A friend of his father found the boy one day stretched upon the hearth, tracing with chalk various lines and angles. "Why do you permit this child," said he, "to waste his time so?" Mr. Watt replied, "you judge him hastily. Before you condemn us, ascertain how he is employed." On examining the boy, then six years of age, it was found he was engaged in the solution of a problem of Euclid.

At this time also, he exhibited considerable mechanical skill. One more anecdote, is, perhaps, worth repeating, as it appears to show *that even while a child he was thinking of the*

ORIGIN AND PROGRESS OF

subjects that occupied so much of his attention in after life. One day Mrs. Muirhead, the aunt of the boy, reproaching him for what she conceived to be listless idleness, desired him to take a book and occupy himself usefully. "More than an hour has now passed away," said she, "and you have not uttered a single word; do you know what you have been doing all this time?—You have taken off and put on, repeatedly, the lid of the tea-pot; you have been holding the saucers and spoons over the steam; and you have been endeavouring to catch the drops of water formed on them by the vapour; is it not a shame for you to waste your time so?"

It is not our intention to give even a sketch of the life of this celebrated man, but we must notice the incident that directed his attention more particularly to the Steam Engine. Watt had by this time become a mathematical instrument maker, and a model of a Newcomen's engine was sent to him to repair. He noticed its imperfections, and contemplated the improvement of which it was susceptible, but he *made no random experiments*: he calculated *every step he took in his enquiry*.

THE STEAM ENGINE.

The first grand defect discovered by Watt, was the much greater amount of steam introduced into the cylinder to raise the piston than was shown by calculation to be necessary. The steam, it appeared, had its temperature lowered by coming in contact with the sides of the cylinder and the piston, which had been cooled by the introduction of the condensing water. Accordingly it occurred to him, that if the condensation could take place at a distance from the cylinder, the temperature of the latter would not be lowered, and a great saving in fuel would be effected.

To carry out his plan, he applied a pipe A,

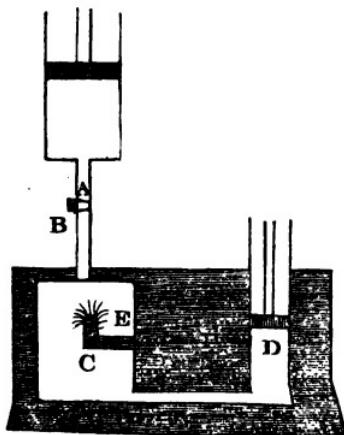


FIG. 7.

ORIGIN AND PROGRESS OF

fig. 7, to the bottom of the cylinder. This pipe was furnished with a stop-cock, and communicating with a large vessel c, kept cool by being surrounded by cold water. Supposing now that the piston has been raised to the top of the cylinder by the pressure of the steam; supposing, also, that the chamber c is a vacuum, produced by the action of the piston d, which is worked by the engine itself. If, while things are in this state, the stop-cock b is turned, the steam from the cylinder rushes down the pipe a, and is instantly condensed, a jet of cold water from the pipe e materially assisting in the production of its rapid condensation. The cock b, being at the same time turned, to shut off all communication between the cylinder and the vessel c, the piston will be driven down by the pressure of the atmosphere, and the temperature of the cylinder and piston will remain unaltered. This caused a great saving in the expense of fuel, and to render the loss of temperature still more trifling, he next surrounded the cylinder itself with an atmosphere of steam, which kept the outside as well as the inside at a proper temperature.

Another great improvement introduced by
32

THE STEAM ENGINE.

Watt, was the employment of steam instead of atmospheric air, for the purpose of forcing the piston to the bottom of the cylinder. This was effected by allowing the steam brought from the boiler to enter alternately above and below the piston, a vacuum being also formed at the same time, at the opposite end of the cylinder ; and thus a machine was made, to all intents and purposes, a Steam Engine, for steam was the only motive power.

It might be imagined that these great discoveries, whose value is at the present day so highly appreciated, would have ensured for their discoverer immediate fame and wealth. Far from it. The invention we have just described, is of the date of 1765. Two years passed away, and he hardly made any progress in attempting the trial of it on a great scale ; and it was not until 1768 he could find any one willing to advance the capital necessary to build an engine of sufficient size. According to his improved plan, in 1769, a patent was obtained for fourteen years, but his partner in the undertaking failed. At length, in 1773, Boulton, of Soho, purchased the share of Dr. *Roebuck*, and having by great interest and ex-

ORIGIN AND PROGRESS OF

pense obtained a renewal of the patent, in 1783 Watt again directed the whole of his attention to the improvement of his **SINGLE ACTING STEAM ENGINE**, as it has since been called. These improvements consisted chiefly in various mechanical contrivances to render the working of the engine more certain and accurate, but did not interfere with the principle of his invention.

It was discovered during the progress of the improvements that took place in the Steam Engine, that an irregularity of motion was produced by the greater or smaller supply of steam afforded by the boiler. To obviate this inconvenience, the fly wheel, so much employed in machinery for the purpose of equalizing motion, was resorted to; but it proved unequal to the emergency. The next invention was the throttle valve, a valve placed in the pipe by which the steam is conveyed from the boiler to the cylinder. The opening and partially closing of this valve either increased or reduced the supply of steam. This valve was moved by the engine man by means of a lever.

Watt, however, soon perceived that the ma-
34

THE STEAM ENGINE.

nipulation of the lever would be impracticable with any degree of vigilance and skill that could be obtained from the persons employed to attend on the engine. Accordingly he connected the lever, by which these motions were regulated, with an apparatus, founded on the principle of the regulator employed in windmills. To this he gave the name of "the governor," and such is its accuracy that there

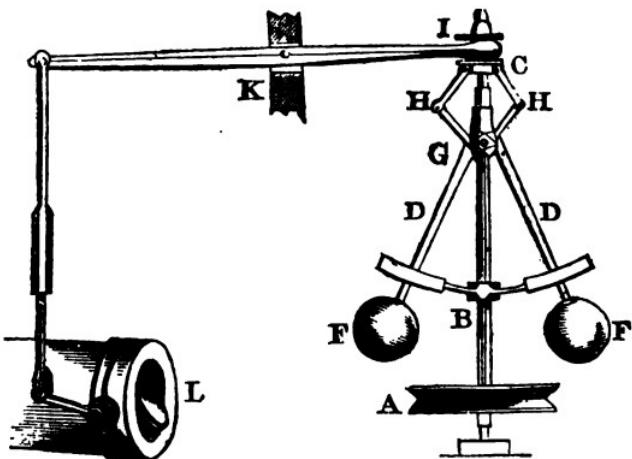


FIG. 8.

was to be seen at Manchester a few years back, in a cotton mill belonging to Mr. Lee, a clock which was set in motion by the Steam Engine used in the works, and which marked

ORIGIN AND PROGRESS OF

time extremely well, even by the side of a pendulum clock.

To understand the action of the governor, let us refer to the engraving, fig. 8: A is a small grooved wheel, over which an endless cord attached to the machinery runs. This grooved wheel is fixed on an upright spindle B. On this the governor is placed. The levers, D, D, to which the balls, F, F, are fixed, work upon a centre at G. The more rapidly the wheel A revolves, the further will these balls separate from each other, on account of the greater centrifugal power they will then have gained. (The property exhibited by a revolving body to fly from the centre round which it moves, is called the centrifugal power, and is evinced in the most trifling matters on earth; in the twirling of a mop, the flight of a stone from a sling, as well as in the mightiest works of the universe, the motions of the celestial bodies.) As the balls separate from each other, the collar C, which slides on the spindle, is drawn downward in consequence of the angles H, H, being thrust out, and as the collar is attached to the end of the long lever I, which works on a centre at K, it draws down the end nearest to

THE STEAM ENGINE.

1; and, consequently, raises the opposite end of the lever, by which means the valve L, in the pipe by which the steam is supplied, is turned partly round, and made to offer a greater obstruction to the passage of the steam, and, consequently the machinery will move more slowly. If, on the other hand, the engine were moving slowly, the balls would fall closer to the spindle; the end of the lever near 1 would be raised; and the valve L opened to allow of the passage of more steam to increase the rapidity of the motion.

This variation in the distance of the balls of the governor from the spindle, depends on a power we have already noticed, centrifugal motion, which is exhibited in the tendency of all bodies in motion round a centre, to fly from that centre. The annexed diagram will, perhaps, render the cause of centrifugal motion more apparent.

It is a well estblished fact that all bodies have a tendency to approach each other if unopposed, and this power, or tendency, bears an exact proportion to the relative magnitudes of the bodies. If we place a moderately sized piece of cork on the surface of the water in a large

ORIGIN AND PROGRESS OF

bowl filled with that liquid, and then scatter over the water small fragments of the same substance, we shall see that the smaller pieces of cork which are near to the larger piece, will approach the latter and cling to its side. Suppose, then, **A**, fig. 9, to be the centre, round

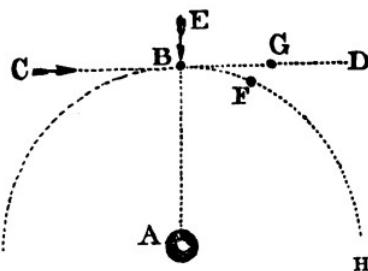


FIG. 9.

which a small body, **B**, is revolving. This body, we are to suppose, was originally set in motion in the direction **C, B, G, D**; and, had it not been for the proximity of the body **A**, it would have continued to move in a straight line until the impetus acquired was exhausted.

But the body **A**, by its power of attraction, gives to **B** a tendency to move in the direction **E, B, A**. Here, then, we have two powers acting on the same body—**E** forcing **B** towards **A**; and the power **C**, pressing **B** forward in the

THE STEAM ENGINE.

direction of G, D. Thus these two powers counteract each other ; but still the onward motion imposed upon B, is not lost : the direction only is changed, and instead of reaching G, as it would if it had continued to move in a straight line, it is bent from its course by the influence of the body A, and reaches F ; and as the two powers still continue to act in the same manner, the original direct course of C, B, is changed into a circular one, B, F, H, &c.

In the instance of the governor, the balls, F, F, have a tendency to fall by their own gravity, while the rods, D, D, attach them to the centre, G, and when they are whirled round, the centrifugal power they acquire by the rotary motion, causes them to diverge, or endeavour to fly off, from that centre, and thus they bring the levers, H, H, and I into action.

Watt soon discovered that the use of the Steam Engine would be much improved if a continuous motion could be produced ; but his Single Acting Engine supplied only an intermitting force, its operations being continued during the descending motion of the piston, *but suspended* during its ascent. The power

ORIGIN AND PROGRESS OF

also acted in a straight line, and he required a modification of the machine by which a continuous revolving motion could be produced upon a shaft or wheel.

Speaking of this new improvement, which led the way to the invention of the locomotive engine, Watt himself observes, "Having made my single reciprocating engines very regular in their movements, I considered how to produce rotative motions from them in the best manner, and among various plans that were subjected to trial, or passed through my mind, none appeared so likely to answer my purpose as the application of the crank in the common turning lathe, but as the rotative motion is produced in that machine by the impulse given to the crank in the descent only of the foot, it requires to be continued in its ascent by the energy of the wheel, which acts as a fly. Being unwilling to load my engine with a fly-wheel, heavy enough to continue the motion during the ascent of a piston, I proposed to employ two engines acting on two cranks fixed on the same axis at an angle of 120° to each other, and a weight placed upon the circumference of the fly-wheel, at the same angle to each of the cranks,

THE STEAM ENGINE.

by which means the motion might be rendered nearly equal, and only a very light fly-wheel would be necessary." This and several other contrivances were adopted by Watt to produce a continuous circular motion, but the crank was discovered to be superior to them all.

Notwithstanding all these improvements, however, the power by which the motion was obtained was still intermittent. Watt, to obviate this inconvenience, reverted to his previous invention, by which the piston was moved both upward and downward by the elasticity of steam. This invention we have already described, and engines constructed on this principle were called "Double Acting" Engines. Since this last improvement was brought into practice, no new principle has been brought to bear upon the construction of the Steam Engine, although numerous mechanical contrivances have rendered its action much more certain.

We have already alluded to the application of steam at a high pressure in the working of the Steam Engine, and, in fact, it was one of *the earliest* applications of steam power, and

ORIGIN AND PROGRESS OF

formed a part of several of Watt's patents, but it was never fairly brought into practice until 1802, when Trevethick's engine was constructed. The high pressure, or non-condensing engine, is much simpler in its construction than either the single or double action engine. In these last, the motion of the piston is chiefly brought about by producing a vacuum by the condensation of the steam. For this purpose, a condensing apparatus, a good supply of water, and the ponderous beam were indispensable ; and, consequently, the engine must occupy a considerable space. In the non-condensing engine, these portions of the apparatus are unnecessary, the piston being raised and depressed by the aid of steam at a high pressure, introduced alternately above and below it. An engine of this description can be so constructed as to occupy but little space ; it can also be moved from place to place ; and after some improvements had taken place, it became a locomotive engine, not only capable of moving itself, but also of driving the heaviest laden vessel through *the water*, or dragging with the rapidity of an *arrow*, *the crowded train* along the iron rail.

THE STEAM ENGINE.

LOCOMOTIVE STEAM ENGINES

STEAM BOATS.

With one or two trifling exceptions, the first application of steam for the purposes of locomotion was to the Steam Boat. Although not many years have elapsed since it was applied in this manner with any practically useful result, it appears to have been contemplated as far back as 1737, when a pamphlet was published by one Jonathan Hull, who, in 1736, had obtained a patent for what may be strictly termed a Steam Boat. As this is the oldest claim on record, although it does not appear that it was ever carried into effect, it may be interesting to make an extract from the patentee's description of his invention.

"In some convenient part of the tow-boat," he observes, "there is placed a vessel about two-thirds full of water, with the top close shut. This vessel being kept boiling, rarifies the water into steam, which being conveyed through a large pipe into a cylindrical vessel

ORIGIN AND PROGRESS OF

and there condensed, makes a vacuum, which causes the weight of the atmosphere to press on the vessel, and so presses down a piston that is fitted into this cylindrical vessel, in the same manner as in Mr. Newcomen's engine, with which he raises water by fire."

" It has been demonstrated that when the air is driven out of a vessel of thirty inches diameter, the atmosphere will press on it to the weight of four tons, sixteen hundred weight, and upwards; and when proper instruments for this work are applied to it, it must drive a vessel with great force." Such was Hull's invention; and the machinery he described for moving a pair of paddle-wheels, was extremely ingenious.

In 1775, a small boat was tried on the Seine, built by M. Perier. It had about the power of one horse, and is said to have been successful, but it was soon laid on one side. In 1781, the Marquess de Jouffray built a Steam Boat, at Lyons, one hundred and forty-seven feet in length, but before the experiment had been fairly tried, the Revolution broke out, *and the inventor was obliged to seek refuge in a foreign land.*

THE STEAM ENGINE.

About the same time experiments were going on in America by James Ramsay, of Virginia, and John Fitch, of Philadelphia ; in Italy by M. Serratti ; and in Scotland by Miller, of Dalswinton. In the latter case an engine was constructed, and put on board a vessel in 1778, and the experiment was so successful that a larger boat was built and tried the following year on the Forth and Clyde canal, but it was laid on one side on account of the great injury it did to the banks.

After this period many were the plans invented to carry out the invention, but with little success. In 1795, Lord Stanhope attempted to propel a boat with paddles resembling the feet of a duck, but the experiment was unsuccessful. Still, however, steam navigation advanced. The Marquess de Jouffray had returned to France, and endeavoured to resume his experiments ; but a M. de Blanch had in the interim obtained a patent ; while the celebrated Fulton, who was at that time in France, was also busy on the same subject, and soon afterwards returned to his native country—America—where the first really successful attempt was made.

Before he accomplished his task, however,

ORIGIN AND PROGRESS OF

Mr. Symington, the American Ambassador at the Court of France, obtained a conditional patent, in 1798, dependent on his successfully navigating a vessel by steam in the following year, at the rate of four miles an hour; but being unable to attain the requisite speed, the road lay open for others. Fulton was the most successful of these. Warned by the failure of his partner (for he stood in that relation to Mr. Symington,) he employed a much more powerful engine. This, in 1807, was put on board a boat built for the purpose of running between New York and Albany, a distance of one hundred and twenty miles. After a failure at first starting, which exposed the anxious inventor to the ridicule of the spectators, he got his boat fairly under way, and accomplished the distance in from thirty to two-and-thirty hours. The astonishment and terror of the good people of Albany, when they saw the moving mass approach, was extreme, and is thus described by an American journalist:—

“ She had the most terrific appearance from other vessels that were navigating the river. *The first* steamers, as many in America yet do, used dry pine wood for fuel, which

THE STEAM ENGINE.

sent forth a column of ignited vapour many feet above the flue, and whenever the fire was stirred, a galaxy of sparks flew off, and in the night had a very beautiful appearance. Notwithstanding the wind and tide were adverse to its approach, they saw with astonishment that it was rapidly coming towards them; and when it came so near that the noise of the machinery and paddles were heard, the crews, in some instances, shrunk beneath their decks from the terrific sight, and left their vessels to go ashore, while others prostrated themselves and besought Providence to protect them from the approach of the horrible monster, which was marching on the tide, and lighting its path by the fire which it vomited."

A few days only elapsed before Fulton's countryman—Stevens—also launched a Steam Boat with success, but Fulton had obtained an exclusive right to navigating the waters of the State of New York. His competitor, therefore, determined on the bold experiment of conveying the vessel to the Delaware by sea. In this he was successful, and thus he was the first man *who navigated the ocean by means of steam.*

ORIGIN AND PROGRESS OF

Leaving our American brethren to improve upon the boats they had already launched, let us turn our attention to Europe, where steam navigation was not introduced until several years later. In 1812, the first Steam Boat was launched on the waters of Great Britain. It was called the " Little Comet," and was built at the Port Glasgow. The engine was only of three horse power, and the vessel had also a great draught of water, both, as it has been since discovered, disadvantageous circumstances for steam navigation. It was soon found that engines of much greater power were required, but, then if you increased the power, it seemed necessary that the size of the engine should be also materially increased, and the room it would then occupy on board the vessel, was more than could be spared. To avoid this increase of size, high pressure engines were employed, but with all the care of the owners, accidents were frequent from the bursting of the boilers. Copper, wrought iron, cast iron, were in turns used in their construction, but it was all in vain; and in America the consequences were more disastrous than even in *Britain*.

THE STEAM ENGINE.

In 1817 a dreadful accident occurred by the bursting of a steam boiler in the Norwich river. The vessel was rent to atoms, so that little remained entire from the stem to the engine room, except the keel and the flooring. Twenty-two passengers appear to have been on board. Of these, six alone escaped unhurt, six were sent to the hospital, and the remainder were killed. This and other accidents attracted the notice of Parliament, and a committee sat to inquire into the causes of these disasters. To endeavour to discover a remedy, many plans were suggested, and afterwards adopted; and since that time, accidents of this nature have been very rare in England. Not so, however, on the other side of the Atlantic. There these dreadful occurrences are frequent. A few years back the Editor of an American paper made the following observations on the subject:—

“ In looking over our file of papers for the last six weeks, we find that we have recorded no less than twelve Steam Boat accidents, attended with a loss in the aggregate of more than one hundred lives. They are as follows: ‘*New England*,’ boiler burst, 16 lives lost;

ORIGIN AND PROGRESS OF

‘St. Martin,’ burnt, 30 or 40 lives lost; ‘Cafstan,’ burnt, 20 or 30; ‘Illinois,’ boiler burst, 13 or 20; ‘Thomas Yeatman,’ boiler burst, 7; ‘Columbia,’ sunk, 4; ‘Paul Pry,’ boiler burst, 1; a total of from 91 to 118 lives lost. ‘George Washington,’ wrecked; ‘Rapid,’ sunk; ‘Black Hawk,’ burnt; ‘Peruvian,’ sunk; ‘Chippewa,’ sunk. Why is it that English Steam Boats are so safe to travellers, and American Steam Boats so unsafe? Why is it that more lives are lost on board American Steam Boats in one year, than on board English Steam Boats in ten years? Cannot the difference be partly accounted for by the fact, that in England very strict regulations are prescribed and enforced by the Government in relation to Steam Boats, and in the United States none? If not, can any man tell how the fact is to be accounted for?’

The editor of another paper, published in 1835, observes, “It has been estimated that 1,500 persons have lost their lives in the United States during the last three years by the bursting of steam boilers.” Let not, our readers, however, be terrified at *these* alarming statements. They will perceive, when the causes of the bursting of

THE STEAM ENGINE.

steam boilers are explained, that with the precautions now taken in their manufacture and management, the two principal, nay almost sole causes of these dreadful accidents, can be guarded against with almost perfect certainty. One cause consisted in the boiler not being sufficiently strong to bear the pressure; but at the present day boilers are always made so as to bear a pressure two or three times greater than that to which they are intended to be subjected, and to ascertain that they are capable of bearing this pressure, the boiler is "proved." This is done by filling it with water, and afterwards by means of a forcing pump, causing the fluid to press with the requisite force against the inner part of the boiler. The law by which the pressure of fluids is regulated, we have already explained.

Another element of safety is the application of a safety valve, which being loaded with a certain weight, rises when the pressure from within exceeds that weight, and allows the steam to escape; and so careful are the owners of steam vessels of the safety of their passengers in *this country*, that, in general, there are *two safety valves applied to the boiler*, one of

ORIGIN AND PROGRESS OF

them out of the reach of the engineer, so that he may be unable to tamper with it by overloading it. Here, perhaps, our readers will ask, Is it possible any man can be so careless of his own safety as to risk an accident when he himself would be most exposed to danger if it occurred? Such things are, and some foolhardy men have, although rarely, acted in this manner, for the engineer is as proud of the speed of his boat, as the jockey of the swiftness of his horse, and each of them will, on occasions, risk his own life to excel a rival. But even should this be the case, there is scarcely any danger, for at the present time, scarcely any high pressure engines are employed by the English in steam navigation, and the following evidence, given before a committee of the House of Commons, by Mr. Henry Maudslay, the eminent engineer, shows the almost impossibility of accident when low pressure, or condensing, engines are employed, and at the same time it exhibits the recklessness at times displayed by men for the sake of rivalry, and the danger of the high pressure principle when placed under the control of careless engineers.

THE STEAM ENGINE.

"As far as my opinion goes," he observes, "I would not go from here to Margate in a high pressure boat, because there are many reasons why that may become much more dangerous, and no more advantageous to the public generally, or to the individuals. A low pressure engine has a very high power; a high pressure engine has a higher power according to its height of steam. It is pretty well understood that a gentleman who engages in a Steam Boat Company, seldom attends to the engine himself, but leaves it to his men. I built the 'Regent' Steam Boat last summer, with a low pressure engine. There was a dispute between two men, and one of them swore that he would blow his boiler up but he would beat the 'Regent' in coming up. The man certainly did exert himself as much as he could, and kept his steam as high as he could get it, and it flew out of the safety valve very frequently; and he hurt his boiler materially by doing so, but he did not beat the 'Regent'; but if it had been a high pressure engine, he would either have beat her or blown up his boiler, because he had the power in his own hand."

ORIGIN AND PROGRESS OF

" Again," he observed, when asked if the engineer could not fasten down the safety valve in a condensing engine, " it would be folly to do so, because if the engineer be at all acquainted with his business, he must know that if the steam be raised beyond five or six pounds per inch in a condensing engine, the power of the engine will not thereby be at all increased." Thus we see that as matters are at present conducted, there is an extremely small risk of danger on board an English Steam Boat. In most steamers of large size, two engines are employed to move the paddle wheels, and in that manner a more steady motion is obtained.

By noticing the accident that occurred in 1817, we somewhat anticipated our accounts of the progress of steam navigation. The " Little Comet," as we have observed, first plied for hire on the Clyde in 1812. The river then was a shallow stream, choked up with sand banks, and intersected with rocks; but since that time, by the enterprise of the inhabitants of Glasgow and Greenock, it has been rendered navigable to boats of great burthen, and the Clyde has become celebrated for its *river and sea-going* boats, for it was not long

THE STEAM ENGINE.

before the boats ventured into the deep waters of the ocean.

The first Steam Boat that plied on the Thames, was "The Margery," a vessel of seventy tons burden, and fourteen horse power; and soon afterwards, another boat, "The Thames," appeared. The first of these boats went from London to Gravesend in a day, and returned the next. The "Thames," however, promised to convey passengers there and back in the same day.

The appearance of these boats on the river, soon drove out of the field all the passenger sailing packets. Even the much improved Gravesend boats, which left Billingsgate regularly at the time of high water, soon lost all their patronage ; and yet the two steamers by which they had been driven out, were but sorry craft, when compared with the passenger boats of the present day. The accommodation was bad, and the clanking of the engine enough to give a nervous patient the headache, while the stench of the foul grease with which the machinery was supplied, had a strong tendency to produce sea sickness even in the smoothest water. Some idea may be formed of the im-

ORIGIN AND PROGRESS OF

crease of steam navigation by glancing at the following Table, which contains the number of steam vessels registered in some of the principal ports of the United Kingdom in 1845 :—

London	261
Newcastle	146
Glasgow	
Greenock and	}
Port Glasgow	70
Liverpool	42
Dublin.....	35
Bristol.....	27
Hull.....	25
Stockton	23
Southampton	21
Sunderland.....	18
Aberdeen	14
	—
	682
At other Ports	193
	—
	875
	—

Great was the alarm created in the minds of the watermen on the Thames by the increase of steam locomotion. Their vested interests were interfered with, and nothing but *ruin* stared them in the face ; but, as in the case of railway travelling, the possessors of

THE STEAM ENGINE.

the former means of conveying passengers to different parts of the river, soon found that although the business of their rivals had increased to an enormous extent, their own employment was also rapidly extended, and the easy exertion of conveying passengers on board the various steamers amply compensated them for the loss of long fares to Battersea, Chelsea, Putney, and Richmond ; and below bridge to Greenwich, Woolwich, or Erith.

There were at this time, and for some years afterwards, regular rowing boats from London to Greenwich, the fare being eightpence, and as they performed their voyage either with or against the tide, the labour was enormous, and the payment insufficient, and yet even these men exclaimed vehemently against the innovation. Their vested rights were interfered with. To make up for supposed losses, the utmost extortion was resorted to ; and timid persons were afraid to enter a wherry to be placed on board a steamer. The consequence of this was, the Steam Boat Companies were obliged, in self-defence, to erect numerous piers on the banks of the river, where their passengers were able to embark or disembark.

ORIGIN AND PROGRESS OF

The certainty and cheap rate at which the public were enabled to travel by the new conveyances, excited an ardour for travelling among the whole community. At first this was exhibited in the formation of pleasant excursion parties to Richmond, or Gravesend, but this was not sufficient; rival Steam Boat Companies put forth all their resources, and, in the first instance, a visit to her Majesty's fleet at the Nore was promised, returning on the same day, and including several hours for recreation at Sheerness.

Soon, however, it was discovered that Margate, and even Ramsgate, could be reached, and the voyagers brought back to their own homes in London, in the course of one summer's day. Did a society wish to take a benefit in aid of its funds, a Steam Boat was hired, and an ample freight of happy souls crowded her decks. Every one enjoyed himself after his own fashion. The religious part of the community, who eschewed dancing and noisy amusement, hired boats on their own account, and passed the time in a manner more congenial to their feelings. The members of Temperance Societies were not behindhand,

THE STEAM ENGINE.

but no intoxicating liquors were to be found among their stores, their drink being confined to coffee, tea, ginger beer, lemonade, or a compound called "gingerette," a strong decoction of various spices, the flavour of cloves being predominant; but, alas! for the consistency of the passengers, the smoking of that noxious weed, tobacco, was not forbidden.

Perhaps a visitor from a foreign land, if he wished to gain some idea of the populousness and prosperity of the great metropolis, could not do better than to sail up our noble river on some fine summer's day, and notice the excursion boats and others, as they glide steadily over the smooth waters of the Thames, their masts decorated with colours of various hues, and their decks crowded like ant hills with happy groups of people, while bands of music on every vessel enliven the scene.

The ball was by this time brought into play. A visit to the banks of the Thames was not sufficient, and Rail and Boat united to accommodate the migratory propensities of the multitude. What would our fathers—we will go no further back—have said, if they had been promised a visit to the Isle of Wight, and a re-

ORIGIN AND PROGRESS OF

turn to their own hearths in London within the space of sixteen hours? They would have looked doubtingly, and considered the matter impossible. Their fathers again would have declared a man was mad, who indulged in such a reverie. Nevertheless the affair has been accomplished, and will no doubt be again effected during our summer months, not *to* the island and back, but *round* it.

It is needless to go into further detail. The Cockney traveller thinks nothing of visiting the Channel Islands to listen to the peculiar French of the Guernsey men, or to go to Calais, but more especially Boulogne, to observe the customs of our mercurial neighbours. It is something to say you have visited the continent, and studied the manners of the people. Some trifling circumstance, however, would not unfrequently prevent the intentions of the traveller being carried into effect, as the following incident will tend to show:—

Two worthy Londoners, smitten with the desire to see foreign lands, determined on a visit to Boulogne. They arrived there in due course, but talking over their amusements *in England*, the discourse turned upon the

THE STEAM ENGINE.

scientific game of “skittles,” in which it seems they were both adepts, and as they could not very well agree upon the subject, resort was had to that simple mode of deciding an argument—a bet. One of their fellow passengers had informed them there was an excellent skittle ground at some Anglo-French Hotel in Boulogne.

Being safely landed at their destined port, they proceeded without delay to the skittle-ground, where they found an English lad ready to wait on them. As the day was far spent when they reached their resting place for the night, they were unable to decide their wager before the arrival of bed-time. In the morning the game was concluded, and but just concluded, when the bell of the steamer was heard, and they were obliged to hasten on board lest they should lose their passage, and they thus returned to London bearing with them their experience of foreign travel.

By this time Steam Boats were plying to every part of Europe, and on the Mediterranean. At length two companies started to try what steam *could* do in crossing the Atlantic. *This idea was so bold that half the community*

ORIGIN AND PROGRESS OF

became incredulous. A calculation was made as to the quantity of coals that would be required, and it was clearly shown, on paper, that no steam vessel could carry a sufficient supply. The speculators, however, proceeded to their work, and the "Great Western" and the "Sirius" were built. The "Great Western" was built at Bristol in 1837: it measured 679 tons, was of 400 horse power, 207 feet, 1 inch in length, and 18 feet in breadth. The "Sirius" was built at Leith, in the same year. It was smaller than the rival boat, its measurement being only 412 tons: it was 250 horse power, 178 feet 4 inches in length, and 25 feet 8 inches in width.

The "Sirius" started from Cork on the 4th of April, 1838, and the "Great Western" on the 7th of the same month from Bristol. They started, as we have seen, nearly at the same time, while both of them reached New York on the same day; and on the 28th of April the citizens of that capital were surprised at the appearance of two large steamers in their waters, one of them—the "Sirius"—having been nineteen days on her passage, the "Great Western" having performed the same distance in some-

THE STEAM ENGINE.

thing less than sixteen days; while the average passage of their fine sailing vessels—the “Liners”—had been thirty-seven.

These large steamers having performed their duty, several others were likewise built for the passage of the Atlantic.

Where built.	Name.	Date.	Ton-nage.	Horse power	Length on upper deck.	Breadth within paddle boxes.
					Feet	Ft. in.
London	British Queen	1838	2,016	500	245	40 0
London	President	1839	2,366	600	243	41 0
Bristol	Great Britain	1843	1,843	1,000	274	48 2

The unfortunate “President,” after making several trips in a most satisfactory manner, became due on her return voyage in April 1841, but she was never more heard of. How she was lost was never known, but it has been supposed that she fell in with some icebergs, many of which had broken loose from the northern seas, and were known to be floating about in more southern latitudes. This disaster, however, did not check the enterprise

ORIGIN AND PROGRESS OF

of the ship builders ; and, in 1843, the “Great Britain,” of less tonnage, but of greater length and power, was launched at Bristol. She performed several trips to America and back admirably, but during her outward bound voyage in the autumn of 1846, this magnificent vessel run ashore in Dundrum Bay on the coast of Ireland. In addition to these large Atlantic boats, several others have been built to ply between London and Edinburgh, of more than a thousand tons burthen, and four hundred horse power.

Our Eastern possessions have also been brought within the reach of the giant power of steam ; vessels regularly leaving Southampton twice in every month ; proceeding up the Mediterranean to Malta and Alexandria ; then a short land passage across the Isthmus of Suez brings the traveller to the Red Sea, where a steamer is in waiting to convey him to Bombay ; and this passage from Southampton to Bombay is effected in from thirty-four to thirty-five days, or if he choose to take the benefit of the railways across France, the journey may be performed in about four or five days less !

But still, great as these undertakings have

THE STEAM ENGINE.

been, greater are in contemplation ; and a scheme is now on foot to establish a regular line of steam packets round the globe itself, by crossing the Atlantic to the Isthmus of Darien, thence a short overland trip is to carry the mail, or traveller, to the Pacific ; from thence to the South Sea Islands and China ; and thence, merely turning one or two thousand miles out of the way, to pay a visit to Australia ! proceed to Hindostan ; up the Red Sea to Suez ; across the Desert to the Mediterranean ; and so back again to the British shores ; and all this is to be effected by the employment of the elastic force of the vapour of a few gallons of water !

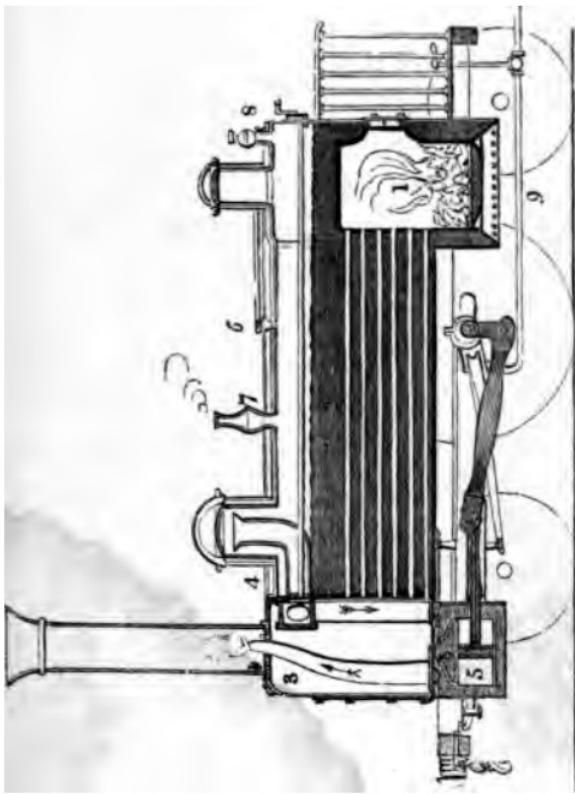
Steam Boats of recent construction, as we have already said, have in general two engines to move the paddle wheels, and produce a steady motion. The two following engravings will give a tolerable idea of the internal arrangement of a Steam Boat and its pair of engines.

ORIGIN AND PROGRESS OF

THE RAILWAY LOCOMOTIVE
ENGINE.

We have already given an account of the rise and progress of railway travelling, the principle on which the power of the Steam Engine depends, and its application to the propulsion of vessels through the water. In the Railway Locomotive, we have no room for enormous boilers, large working cylinders, or an abundant supply of water for the purpose of condensing the steam. Under these circumstances none but the high pressure, or non-condensing, engine can be employed. We want our iron steed, whose heart is flame and life breath steam, to be strong, compact, and active. A mile a minute will surely not hurt his sturdy frame; but to turn the wheels on which he moves along, the piston must not be idle: short and quick must be its stroke, and a supply of elastic steam must be constantly maintained to *feed its small but insatiate cylinder.*

To effect all this, some alteration was necessary.



SECTION OF THE STEAM ENGINE.

UNIVERSITY OF WISCONSIN-MADISON

THE STEAM ENGINE.

sary in the construction of the boiler. In the first place, as the steam was to be at high pressure, it would have been dangerous to have had a boiler of the usual form, for, in case of accident, the mischief would be very extensive. Such a boiler, also, would have been unable to supply steam with sufficient rapidity to feed the cylinder in which the piston works. Accordingly the boiler is intersected by numerous small tubes, as seen in the section of the Steam Engine. Through these tubes the hot air from the furnace 1, is conveyed. This air, in its passage through the tubes, acts upon a large surface of the water of the boiler, which it quickly raises to the boiling point; and, in this manner, the steam is more rapidly generated. The grating of the furnace being also open to the air, a quick draught is produced. In some instances these tubes are considerably more than one hundred in number, the external diameter of each not being more than $1\frac{1}{2}$ each. The steam thus generated passes in the direction of the arrow in the cylinder, or piston box 5, where it is introduced alternately at each end of the piston, which, it will be seen, moves horizontally, and having thus performed its

ORIGIN AND PROGRESS OF

office, it escapes up the tube 3 into the chimney. The alternating motion of the piston moves a crank attached to the axis of the wheel, and in this manner the Locomotive Engine is driven along with inconceivable speed. A smaller vehicle is attached to the engine called a tender. This contains water, and coke for the engine fire, which is attended to by the stoker, while the engineer regulates the speed of the locomotive or stops it in its course when necessary.

The velocity with which an engine moves depends on the rate at which it is possible to move the pistons in the cylinder, (there are two pistons, one on each side the carriage). By every motion of each piston backwards and forwards, one revolution of the wheels is produced, and by each revolution of the wheels, supposing them not to slip on the rails, the engine advances a distance equal to their circumference. As the two cylinders work together, it follows that a quantity of steam, sufficient to fill four cylinders, supplied by the boiler to the engine, will move the train through a distance equal to the circumference of the wheels, and in accomplishing this, each piston must move twice from end to end of the cylinder ; each

THE STEAM ENGINE.

cylinder must be twice filled with steam from the boiler; and the steam must be twice discharged from the cylinder through the blast pipe into the chimney.

If the wheels be five feet in diameter, their circumference will be fifteen feet seven inches. To drive a train with a velocity of thirty miles an hour, it will be necessary that the engine should be propelled through a space of forty-five feet a second. To accomplish this with five-feet wheels, therefore, they must be made to revolve at the rate of three revolutions to a second, and as each revolution requires two motions of the pistons in the cylinders, it follows that each piston must move three times forwards and three times backwards in the cylinder in a second; that steam must be admitted six times a second, from the steam chest, to each cylinder, and discharged six times a second into the blast pipe from the cylinder. The motion, therefore, of each piston, supposing it to be uniform, must divide a second into six equal parts, and the puffs of the blast pipe in the chimney must divide a second into twelve equal parts.

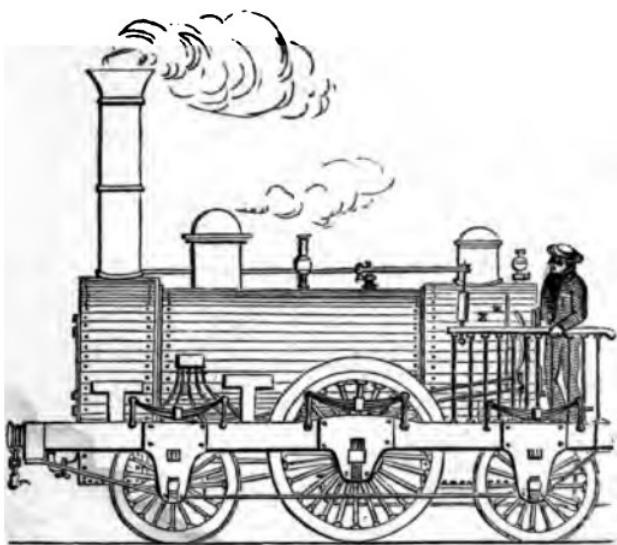
It is evident that such rapid movements as

ORIGIN AND PROGRESS OF

these, would be the cause of great wear and tear to the machinery. Attempts were, therefore, made to remedy the defect, and to obtain greater speed with an equal, or diminished, rate of motion. To accomplish this, wheels have been employed five feet and a half, or six feet, in diameter; and, in some instances, even ten-feet wheels have been made use of, but these last, we believe, have not proved so successful as it was anticipated.

We have already shown that the boiler of a locomotive engine is formed of a series of tubes for two reasons, one of which is safety, for if by any accident one of these tubes should burst, the damage likely to ensue would be but trifling, and a new tube could be easily inserted in the place of that which was rendered useless. But, as if to make assurance double sure, the tubular boilers of locomotive engines are also furnished with two safety valves, one of which is locked up, and, consequently, out of the reach of the engineer.

At that extremity of the engine at which the engineer stands, is placed the whistle, whose shrill and startling sound is so frequently heard, rousing the sleeper from his



STEAM ENGINE.



THE STEAM ENGINE.

rest, and startling, at times, even the most stoical traveller. Fig. 10 represents this part

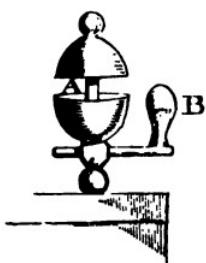


FIG. 10.

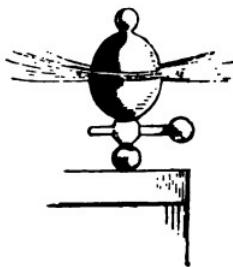


FIG. 11.

of the apparatus when not in action. It consists of two hemispheres of brass; the upper, which is solid, being attached to the stem *A*, while the lower cylinder is partially hollow. By turning the handle *B*, the upper hemisphere is brought close to the lower as in fig. 11, and the same motion allows of the escape of steam, which rushing between the edges of the two hemispheres, produces the shrill sound with which we are all so well acquainted.

ORIGIN AND PROGRESS OF

THE ATMOSPHERIC RAILWAY.

Hitherto we have described the Steam Engine as employed in dragging a train of carriages along a railway, in the same manner as a horse might perform the same task, but a new description of railway has been constructed within these few years, called the "Atmospheric Railway." On railways of this construction, the moving power is the pressure of the atmosphere, which acts upon a kind of travelling piston, in a long tube with a groove, a vacuum being created in front of it by the exhaustion of the air. This is effected by a powerful air pump, worked by a stationary engine. As the carriage passes, it raises a valve by which the groove is covered, and rendered air-tight. As soon as it has passed, the valve again falls down. It is covered with an adhesive substance, easily melted by the application of heat; and to cause it to melt, and again seal the tube hermetically, a small vessel, containing hot coals, travels

THE STEAM ENGINE.

along with the carriage. The first Atmospheric Railway was established between Kings-town and Dublin; and another was laid down between New Cross and Croydon, but this latter has been for some time discontinued. It is said that the carriages move at a more rapid rate along an atmospheric tube, than when drawn by engines on a railway.

LOCOMOTIVE ENGINES ON A COMMON ROAD.

The construction of a railway, as we all know, is an undertaking requiring an immense outlay, and it occurred to the speculative mind of Mr. Goldsworthy Gurney, a medical gentleman and scientific chemist of Cornwall, that Locomotive Engines might be so constructed as to draw carriages along a common road. It is true greater power would be requisite to draw an equal load, but then the expense of the railway would be saved. Accordingly Mr. Gurney began the construction of his engines.

ORIGIN AND PROGRESS OF

These he intended to manufacture as light as he possibly could make them; but imagining that under such circumstances the bite, or adhesion, of the wheel to the ground would not be sufficient to propel the carriage, he went to a vast deal of trouble and expense in the contrivance of levers and propellors acting on the ground, something after the manner of a horse's foot, to drive the carriage forward. As soon, however, as he had fairly started his engine, he found that the adhesion of the wheels to the ground, was quite sufficient, not only to propel the carriage on level roads, but even to enable it to pass over hills of no trifling elevation. In this manner he ascended all the hills between London and Barnet, London and Stanmore, Brockley Hill, and even old Highgate Hill.

It was very clear a large boiler was less able to be used in this description of engine than in any other, and accordingly various plans were resorted to. To effect rapid generation of steam, the water was exposed to the action of the fire in narrow tubes, or between plates of metal placed close to each other; nay, the very bars of the grate were hollow, and afforded their quota of steam. There is one curious fact

THE STEAM ENGINE.

connected with Mr. Gurney's boiler which deserves notice, showing as it does the advantage of the knowledge of chemistry even in the construction of a boiler.

The small tubes of which we have spoken, on account of the intense heat by which they are surrounded, soon become filled with steam bubbles. Now, if these tubes were horizontal, the steam might ultimately nearly fill the tube. To prevent this, the tubes are placed in a slanting position, so as to allow the steam bubbles to rise through the water without opposition. Perhaps it may be asked, what mischief would have arisen if the steam had remained in the tubes? The water being driven out by the steam, the pipe would have become red hot; and it is a well known fact that water, when exposed to an intense heat, is decomposed, changed into its original elements, two gases, oxygen and hydrogen, and these two gases being thus separated, become highly explosive, and hence arises the danger of allowing the steam to fill the tube.

By a very ingenious contrivance, the engineer *when he brings his carriage to the foot of a hill, is able to increase the pressure of the*

ORIGIN AND PROGRESS OF

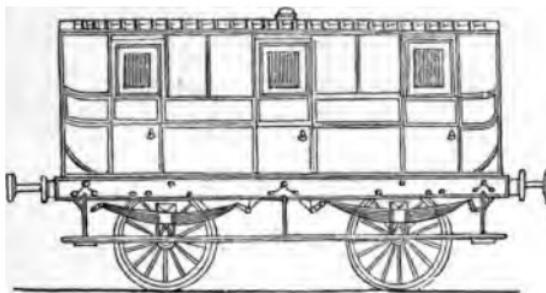
steam to an enormous extent, for while the usual pressure on the piston is not more than from 30lb. to 40lb. on the square inch, he has a supply at command equal to from 100lbs. to 200lbs. Several other projectors of steam carriages for common roads also appeared. Among which, the most successful were Messrs. Maudslay and Field, Colonel Macerone, and Mr. Scott Russell. The difficulties, however, that stood in their way, were numerous. It was supposed that the wheels of these steam engines would cut the roads to pieces; that horses would be frightened; and that the boilers must inevitably burst. One of their real difficulties was the heavy tolls imposed by Government; and at length, after the expenditure of much money, and many not unsuccessful experiments, steam carriages ceased to appear on the common roads.

We have now shown our readers how the power of steam, in the first instance, like a giant chained, was compelled to raise the water from the bowels of the earth. Soon, however, although still bound down, it set in motion the *most complicated machinery*. At length, freed

THE STEAM ENGINE.

from its chains, the giant lightly sprang into the fast sailing boat, and plied his oars so lustily that the sailors hauled down their useless sails, and looked on with wondering eye. But see again, he has usurped the land, and train upon train of heavily laden carriages are hurled along the iron rail with a rapidity enough to make the gazer giddy.

Where next shall we see the monster steam ? Will he hold out the hand of fellowship to the aeronaut, and mounting into the sky along with him, thus complete his triumph by lording it over water, earth, and air ? Who knows ?

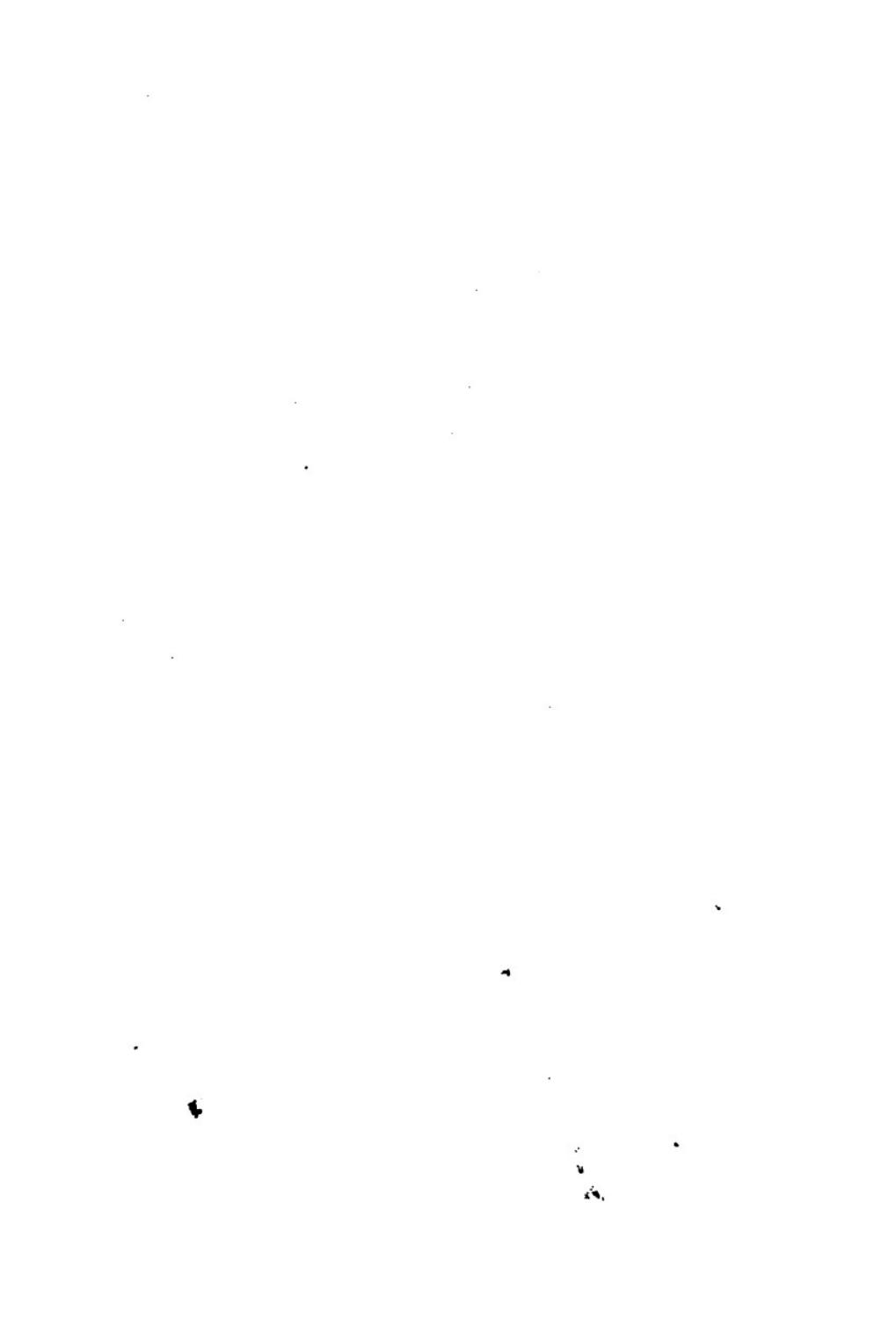


WILHELM WOLFGANG JO ALEXANDER



INTERIOR OF A STATION.

THE UNIVERSITY OF TORONTO LIBRARIES
SERIALS ACQUISITION UNIT





RAILWAY WITH ELECTRIC TELEGRAPH.



THE

ELECTRIC TELEGRAPH.

ORIGIN AND PROGRESS OF TELEGRAPHIC COMMUNICATION.

I'll put a girdle round about the earth,
In forty minutes.

SHAKESPEARE.



THE words placed by Shakespeare in the mouth of his "Robin Goodfellow," conveying the idea of girdling this terrestrial globe in forty minutes was no doubt, at the

B

ORIGIN AND PROGRESS OF

time he wrote, considered a vast stretch of the poet's imagination, and no one could then have dared to suppose that the day would arrive when they would become a mere truism,—in reality a far too modest statement of the fact—for we know not how fast the principle called Electricity travels, no appreciable space of time elapsing between its starting and return on any line of Telegraph at present in use. All experiments hitherto made to determine its velocity, concur in showing it to be so great, that for any length of line likely to be used in practice, time may be altogether neglected.

The idea of communicating information by means of signs has occurred even to uncivilized man. The North American Indians convey intelligence from hill to hill by throwing about their arms with or without a staff in the hand, by spreading their cloaks, holding up skins, &c.; and even the least improved of the Hottentot race, the Bosjcsmans, men, probably, as low in the scale of humanity as the wild native of New Holland, communicate with each other by arranging fires on the sides of the hills in various directions.

Passing over a description of the means of

THE ELECTRIC TELEGRAPH.

conveying information to a distance by means of sound, such as the notes of a trumpet, the beat of a drum, or the loud clang of the deep-toned Chinese gong, it will be as well, perhaps, before we enter upon the subject of Electricity, employed as a means of conveying information from place to place, to look back to the origin of Telegraphs, as they existed before that agent was employed. On referring to the pages of history, we find that some invention of this nature was in use among the ancients, but as our information on this subject is extremely imperfect, we will begin in more modern times, and give a short account of the invention and improvement of the well-known Telegraph on the roof of the Admiralty, which in time of war was so frequently seen lifting its huge black arms, and holding them out in various positions to the astonishment of the assembled crowds, who were completely in the dark as to the purport of the mysterious message the moving monster was delivering; it might be the news of a victory or of a defeat, of a shipwreck, or the sailing of the fleet, or, perhaps, the mere notice of the arrival of some long expected vessel in port.

ORIGIN AND PROGRESS OF

For this purpose, we must consult the Marquis of Worcester's "Century of Inventions." His account of his invention, No. VI., is as follows :—" How at a window as far as eye can discover black from white, a man may hold discourse with his correspondent without noise made or notice taken ; being according to occasion given, and means afforded, *ex re nata*, and no need of provision beforehand ; though much better if foreseen and means prepared for it, and a premeditated course taken by mutual consent of parties." Thus much is said by the Marquis, who also asserts that he had discovered, " A way to do it by night as well as day."

The first practical Telegraph was that of Dr. Hooke, the mathematician, an inventor of many ingenious mathematical instruments, and was described by him in a paper read before the Royal Society in 1684. His method consisted in exposing, in succession, at least as many different shaped figures or signs as the alphabet consists of letters. If used in the day time, they might be squares, circles, triangles, &c. ; and at night, torches or other lights disposed in a certain order. These characters or

THE ELECTRIC TELEGRAPH.

signs were to be brought forward from behind a screen being attached to a moveable rod. Of this Telegraph the stations were to be at such convenient distances as to enable the signals to be seen with a moderately powerful telescope. It is very evident, however, that this plan, although clever, was at the same time very complicated on account of the number of signals. But the doctor himself was so certain of its practical utility that he observed, “the same character might be seen at Paris within a minute after it had been exposed at London.”

At the end of the eighteenth century a great variety of forms were given to the Telegraph, the principal object being to simplify the mechanism. The description of Telegraph employed by the English Government from 1795 to 1816, was the invention of Lord George Murray, and consisted of six shutters painted black, any of which could be opened at pleasure, the different letters and figures being indicated by the situation of the open shutter.

In 1816 the Telegraph, or Semaphore, at present on the roof of the Admiralty was

ORIGIN AND PROGRESS OF

erected.* It was invented by Sir Home Popham, and consisted simply of an upright pole with two moveable arms, placed as in the annexed cut.

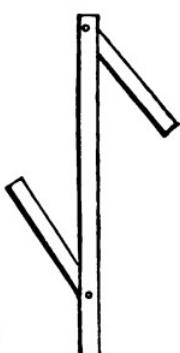


FIG. 1.

It was extremely simple, but at the same time there were a sufficient number of changes in the positions of the arms to give it the requisite power. This last improvement was so great that the officers employed in working it, declared that they could see its arms as distinctly with the naked eye as they could the shutters

* The Electric Telegraph is now, however, adopted by the Admiralty, who are hourly receiving messages by this means from Portsmouth.

THE ELECTRIC TELEGRAPH.

of the Shutter Telegraph with the aid of a telescope. We may gain some notion of the efficiency of the two-armed Semaphore, when we learn that it was able to give forty-eight distinct signals ; we had, therefore, in addition to the alphabet and the numerals, thirteen signals which could be used as arbitrary signs, and made to imply long words of frequent occurrence.

There are thus, we see, two methods of imparting information from station to station ; by employing signs representing words, or signs representing letters : the last plan is considered the most correct, and in the long run as rapid as the other, for there is considerable difficulty in hunting out the sentences and words, as we may well imagine, when we learn that some telegraphic dictionaries of arbitrary signals contain as many as from one hundred to one hundred and forty thousand words and phrases.

“ In using the alphabetical symbols, also,” observes a writer in the “ Encyclopaedia Britannica,” “ the sentence was compressed and useless letters omitted, as for instance : ‘ Order the Agamemnon out of harbour, and direct her

ORIGIN AND PROGRESS OF

to proceed to Spithead.' To convey this message alphabetically, it would be quite enough to say, ' Agmemn to Spthead,' or if from ' Spithead into harbour,' ' Agmemn nto hrbr.' In sending these messages it is also very desirable, especially in our foggy climate, that the intelligence to be conveyed should be compressed as much as possible into the early part of the message. By not attending to this rule a curious mistake once occurred during the Peninsular war :—

" The admiral at Plymouth endeavoured to send up a message, but a fog coming on, part of it only reached London in the morning. It began thus: ' Wellington defeated,' and the next letter was obscured by the fog. The anxiety for the remainder may readily be conceived. Luckily the fog cleared off, and the message was completed the same evening, ' Wellington defeated the French,' &c. Now if the message had been in these words, ' The French defeated at,' &c., there could have been no mistake."

Vessels when at sea as we are all aware employ flags as signals to communicate with each other, and yet, notwithstanding the evident ne-

THE ELECTRIC TELEGRAPH.

cessity of the case, it was not until the time of the American war that anything approaching to a code of signals was known in the British navy, and even then, and for some years afterwards, the system was extremely imperfect, until it was improved in 1799 by Sir Home Popham, and again by the same officer in 1816. The Semaphore Telegraph used on land, was also introduced on board ship by him, but it appeared at times to create confusion on account of the apparatus being frequently seen in reverse.

It seems almost impossible to manœuvre a fleet without a code of signals, and how our fore-fathers got on without it, it is difficult to decide. There is one prominent instance on record in which this want of proper signals enabled a French fleet in the Mediteranean to escape from the British under Admiral Keppel. It occurred in 1780. The admiral wished the two vice-admirals under his command to perform a certain manœuvre, but having no signal applicable to the case, he was obliged to despatch a frigate on two errands to carry his orders, and in this manner so much time was lost that night came on, and the *enemy's fleet* contrived to escape.

ORIGIN AND PROGRESS OF

It has been observed, that “for great and important occasions, the exhibition of a flag or flags in some particular part of the ship, might be generally understood to imply, that the fleet should anchor, or tack, or form the order of sailing in two lines, or the line of battle, or some other great movement. The hoisting of a cask at the yard arm, might be understood to imply a want of water, or a hatchet of wood, or a bag of bread and a table cloth was a very significant invitation to dinner; but our forefathers had no means of interchanging freely their wants and intentions. How would Lord Nelson have been able to make his celebrated signal at the battle of Trafalgar, “England expects that every man will do his duty,” had he merely possessed the means of making the few signals known to his predecessors?



THE ELECTRIC TELEGRAPH.

THE ELECTRIC TELEGRAPH.

The plans we have described for communicating information from one spot to another at a considerable distance, were all that were known previous to the invention of the Electric Telegraph, and in the same manner as the locomotive engine has superseded the stage coach, has this new mode of conveying information almost entirely thrown out of use the old fashioned Telegraph. Although the signals given by the two-armed Telegraph may, perhaps, be as easily read as those of the needle Telegraph, (this, however, is doubtful,) yet the instrument is very limited in its application, requires the greatest attention, and is made useless by the least fog. At each station a man must, at intervals of a few minutes, look at the Telegraph at the stations on each side of him to see if they signal him. How incessant, then, must be the attention, and *how great the fatigue!*

ORIGIN AND PROGRESS OF

Most, if not all of our readers, are aware of the existence of a subtle principle—a “ fluid,” as it has been called for want of a better name—known as Electricity : it appears to pervade the whole earth, and to perform a most prominent part in the economy of the creation. This mysterious principle is exhibited to us by its effects, which are seen under different states. If we wish to exhibit one of the effects of this power, we rub a piece of glass or sealing wax briskly, with silk or wool, and we shall find that the glass or wax has obtained the power of attracting small pieces of paper and other substances, and if we repeat the experiment on a large scale by mounting a cylinder of glass on a stand, and subjecting it to friction, while it is whirled rapidly round, the presence of the mysterious principle is rendered evident by a discharge of sparks, and by its being able to impart a shock ; in fact, we have a feeble imitation of the terrible lightning flash. This is, in general, simply called *Electricity*, or, the electricity of friction.

But there is a second state under which Electricity appears, known as *Galvanism*, or *Voltaic Electricity*. In this instance chemical

THE ELECTRIC TELEGRAPH.

action taking place between different substances causes the development of the principle.

The philosopher having in this manner discovered the means of generating the principle of Electricity, or rather of rendering it evident to the senses, had to contrive the means of storing it up, as it were, or directing its course so as to carry out his intentions. In making experiments on this subject, it was soon discovered that Electricity could pass rapidly through metallic substances, while, on the other hand, glass, resin, &c., were found to impede its progress; in fact, to confine it within certain bounds. Hence material objects were called either conductors or non-conductors, according to the properties they possessed.

The difference between frictional and voltaic Electricity seems to be as follows:—

The frictional Electricity of the machine is small in *quantity*, but of great *intensity*, or strength; the voltaic Electricity of the battery large in quantity, but of feeble power. The first passes readily through imperfect conductors, leaps over a break in them, exhibits violent effects, bursts even rocks asunder; the last requires very good conductors, is hindered in its

ORIGIN AND PROGRESS OF

progress by the least obstacle, and stopped by the slightest want of continuity in the conducting wire. An immense quantity of steam quietly arising from a caldron, would represent the one ; and a small volume, compressed in the boiler of a Perkins' gun till it tears the metal asunder, would be like the other.

It is said a very small battery gives a greater quantity of electricity in a minute than a flash of lightning.

We know no more of the cause of Electricity than we do of the vital principle, but notwithstanding this deficiency of knowledge, the ingenuity of the philosopher has taken advantage of its known effects for the purpose of benefitting his fellow men ! A knowledge of the effects of common Electricity, and of the laws by which it is governed, have enabled us to secure our property from the destructive power of lightning, and to divert it from its fatal course. Again we have employed the properties of voltaic Electricity for many useful purposes in the arts, and at last, by combining several of its effects, we have been enabled to communicate with each other at the distance of several hundred miles in an

THE ELECTRIC TELEGRAPH.

interval of time too short to be imagined, or even calculated by the human mind.

When the conducting power of metals was once ascertained, it was not long before the idea of conveying information from one place to another, suggested itself to the mind of the learned world, for experiments had already been made by which it was ascertained that electrical shocks could be conducted through long circuits with *immeasurable* velocity. This was discovered as far back as 1748. At a later date, Mr. Cavallo, the author of a work on Electricity, suggested a method of conveying intelligence by passing a given number of sparks through an insulated wire, in given spaces of time; and some German and American philosophers first projected Galvanic or Voltaic Telegraphs by the decomposition of water, but these last ideas are of recent date.

In 1816 the first practical attempt at the construction of an Electric Telegraph was made at Hammersmith by Mr. Rowland. After making several successful experiments, he observed, "The result seemed to be that that most extraordinary fluid, or agency, Electricity, *may actually be employed for a more practically*

ORIGIN AND PROGRESS OF

useful purpose than the gratification of the philosopher's inquisitive research, the schoolboy's idle amusement, or the physician's tool; that it may be compelled to travel as many hundred miles beneath our feet, as the subterranean ghost which nightly haunts our metropolis, our provincial towns, and even our high roads, and that in such an enlightened country and obscure climate as this, its travels would be productive of at least as much public as private benefit." (At the time this was written, the credulity of the public was frequently imposed upon by the report of various mysterious subterranean sounds having been heard. These sounds were, without hesitation, very wisely referred to some unquiet spirit.)

"Why," he continues, "has no serious trial yet been made of the qualifications of so diligent a courier? and if he should be proved competent to the task, why should not our kings hold councils at Brighton with their Ministers in London? Why should not our Government govern at Portsmouth almost as promptly as at Downing Street? Why should our defaulters escape by default of our foggy climate? And since our piteous inamorati are not all Alpheus

THE ELECTRIC TELEGRAPH.

(Alpheus is a river in Greece that flows partly under ground), why should they add to the torments of absence those dilatory tormentors, pens, ink, paper, and posts ? Let us have electric conversazione offices, communicating with each other all over the kingdom if we can."

Here we have a perfect description of the uses of the present Electric Telegraph, and if Mr. Rowland had but employed voltaic, instead of common, Electricity, there is but little doubt he would have succeeded in forming a useful instrument. As it was, he, in the first instance, established the practicability of passing an electric current through a continuous iron wire eight miles in length. The wire was carried round two strong frames of wood, each containing nineteen horizontal bars, the frames being at the distance of twenty feet from each other. A number of small hooks were fixed to these bars, and the wire was suspended by silken threads : silk being a non-conductor of Electricity prevented the escape of the current, which, consequently, passed along the whole length of the wire, the two ends of which were placed at a short distance from each other.

ORIGIN AND PROGRESS OF

At each end of the wire was placed a pith ball electrometer. The electrometer is a small instrument by which the presence of Electricity is shown. It consists essentially, as will be seen by the engraving,

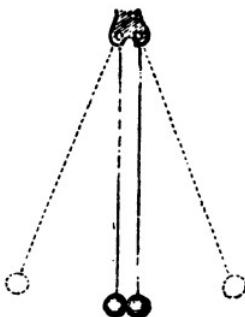


FIG. 2.

of two small balls made of the pith of the elder, and suspended by extremely fine linen threads. When no Electricity is present, the balls touch each other as shown by the centre lines, but when exposed to the influence of a stream of Electricity, they diverge, as we may also see by the dotted lines.

A current of Electricity was passed through the iron wire, and both the electrometers diverged at the same instant; and when the wire was touched with the hand, and the Elec-

THE ELECTRIC TELEGRAPH.

tricity discharged, they, at the same time, returned to their original state. When any person took a shock through the whole length of wire, and the shock was compelled to pass through two insulated inflammable air pistols, one connected with each extremity of the wire, the shock and the explosion seemed to occur quite simultaneously.

If, again, when the spark was compelled to pass through the gas pistols, any one closed his eyes, it was impossible to distinguish more than one explosion, although both pistols were discharged. "Thus, then," he continues, "three of the senses, sight, feeling, and hearing, seemed to receive absolute conviction of the *instantaneous* transmission of electric signs through my pistols, my eight miles of wire, and my own proper person."

Having thus satisfied himself of the power of transmitting Electricity, he, in the next place, directed his attention to the means of communicating information from one extremity of the wire to the other. He dug a trench in his garden five hundred and twenty-five feet in length, in which he buried an iron wire *enclosed in a glass tube*. He then fixed a thin

ORIGIN AND PROGRESS OF

brass plate on the seconds arbor of two clocks, one at each end of his buried wire, each clock beating dead seconds. The brass plate was divided and marked with letters and figures, and a few short sentences. Over this engraved plate, another plate of the same material was placed, having a long slit made in it from the circumference to the centre, so that as the engraved disk was carried round, different figures and letters were seen through the slit.

In order to work this Telegraph, an electrometer, such as we have just described, was placed over the disks, and connected with the wire. All being thus prepared, the party about to send the message waited until the letter or figure he wished to transmit was seen through the pierced disk. The wire was then charged from a small electrical machine, and the balls of the electrometer diverging at both ends at the same time, the party receiving the message would look to the letter then visible at his end of the Telegraph and copy it, for since the clocks both beat seconds, the letter visible at one end would be the same as that seen at the other, and in this manner the required *words* could be spelt or figures transmitted.

THE ELECTRIC TELEGRAPH.

When this plan was promulgated, various objections were made to it. It was said the wire would by degrees become so highly charged with Electricity as to keep the pith balls constantly in a state of divergence, and that the glass tube would be liable to injury, &c., by the action of heat and cold. Another objection most strongly insisted on was, that the subterranean part of the apparatus might be "injured by an enemy, or some mischievously disposed person." To this objection the inventor replied :

" If an enemy had occupation of all the roads which covered the wires, he could undoubtedly disconcert my electric signs without difficulty ; but this case only relates to invasions and civil wars : therefore let us have *smokers* enough to prevent invasions, and kings that love their subjects enough to prevent civil wars. To protect the apparatus from mischievously disposed persons, let the tubes be buried six feet below the surface of the middle of high roads, and let each tube take a different road to arrive at the same place.

" Could any number of rogues, then, open *trenches* six feet deep, in two or more different

ORIGIN AND PROGRESS OF

high roads or streets, and get through two or more strong cast iron troughs in a less space of time than forty minutes? If they could, render their difficulties greater by cutting the trench deeper, and should they still succeed," continues our author, his anger rapidly rising, "in breaking the communication by these means, hang them if you can catch them, curse them if you cannot, and mend it immediately in both cases. Should mischievous devils from the subterranean regions—namely, the cellars—attack my wire, condemn the houses belonging thereunto, which cannot escape detection by running away."

Ingenious as this idea was, the practical objections it offered prevented its adoption, and Government also appears to have discouraged the inventor. "Lord Melville," he observes, "was obliging enough in reply to my application to him to request Mr. Hay 'to see me on the subject of my discovery,' but before the nature of it had been yet known, except to the late Lord Henniker, Dr. Rees, Mr. Brande and a few friends, I received an intimation from Mr. Barrow to the effect, 'that Telegraphs of any kind were then wholly unnecessary, and that

THE ELECTRIC TELEGRAPH.

no other than the one now in use would be adopted !' I felt," concludes the author, "very little disappointment, and not a shadow of resentment on the occasion, because every one knows that Telegraphs have long been great bores at the Admiralty."

In this instance, we see frictional Electricity only had been resorted to, but as soon as the happy idea arose of employing the voltaic or galvanic battery, the improvement of the Electric Telegraph rapidly advanced. One reason frictional Electricity cannot be applied, is that the insulation must be very perfect, for its power of overcoming obstacles in its path, gives it a tendency to escape from its conducting wire, if the supports are the least damp. Now voltaic Electricity is not intense enough to pass off in this manner, and if we afford it a good continuous conductor, slight damp will not affect it. It must be borne in mind that both kinds choose the shortest and easiest path.

Before we proceed, however, to a detailed account of the Electric Telegraphs at present in use, it will be as well to explain the manner in which voltaic Electricity is excited. When *two metals, such as zinc and copper, acted upon*

ORIGIN AND PROGRESS OF

in different degrees by an acid, are placed in a vessel of water, containing a small quantity of some kind of acid, and are made to touch one another, a chemical action is established, and a stream of Electricity passes from one to the other, but if we separate the metals, these effects instantly cease.

If we now connect the metals by means of a wire, the current is reproduced, thus showing that voltaic Electricity, in the same manner as common Electricity, can pass along a metal wire; but if we join them by a piece of wood or glass, we fail in our attempt, for, as we have already said, these last substances are not capable of conducting Electricity. Among the best conductors of Electricity, we find every kind of metal, charcoal, acids, saline solutions, water, living animals, and these possess the power of conduction in various degrees, metals being the best conductors. Among the non-conductors are shell-lac, amber, resins, glass, silk, &c.: of these shell-lac is the best non-conductor.

If we lengthen the wire that connects the two metals or diminish its size, our results become less evident, till at a certain limit they

THE ELECTRIC TELEGRAPH.

entirely cease, showing that the electricity has not sufficient power to traverse a long wire. Let us now take another vessel with zinc and copper plates similar to the first, and connect the metals in both the vessels as shown in the diagram, fig. 3,

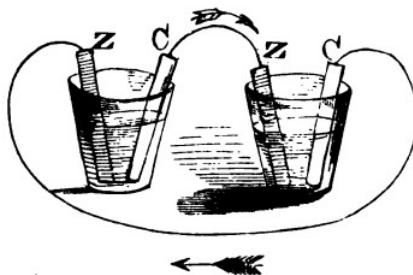


FIG. 3.

the current evolved by these two series of plates passes readily from one end to the other of the long wire ; it has more *intensity* given it, and approaches more nearly to frictional Electricity, and by increasing the number of plates of metal, and connecting them with each other by means of wires, we can transmit the electricity to any distance. The arrows show the direction taken by the current : it passes from the zinc to the copper through the water, which, when rendered acid, is an ex-

ORIGIN AND PROGRESS OF

cellent conductor. From the copper it passes along the wire to the zinc plate; from thence to the next copper plate, until at length it leaves the apparatus by the last copper plate, and passing along the long wire, it again enters by the zinc at the opposite extremity, and in this manner the circuit is continued as long as chemical action goes on in the "battery," as the apparatus is termed.

There are various descriptions of batteries, some of which are better adapted than others for different purposes. That which is found most convenient for the Electric Telegraph, is the trough battery invented some years back by Dr. Wollaston.

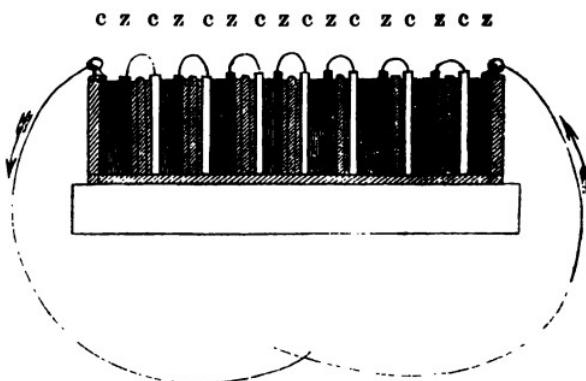


FIG. 4.

THE ELECTRIC TELEGRAPH.

Fig. 4 is a section of one of these batteries : it consists of an earthenware or wooden trough formed into cells, in each of which is a piece of copper and amalgamated zinc. When we say amalgamated zinc, we mean a plate of zinc rubbed over with mercury, by which means a thin coating of amalgam of zinc and mercury is formed. This causes a more regular action of the acid and water on the zinc. The battery cells, in this instance, are not filled with water and acid, but with dry and perfectly clean sand, and when about to be used, the sand is slightly moistened with dilute sulphuric acid.

Batteries of this description are singularly constant, having been known to remain in action during a period of from two to five months with only the addition at times of a little more acid solution. The number of cells in these batteries varies from twelve to sixty pair of plates according to the duty to be performed. Fixed to the last plate, at each extremity of the trough, is a screw to which a wire can be attached, as shown in the diagram, fig. 4. The use of this battery will soon be shown. In the meantime, it must be remembered that the

ORIGIN AND PROGRESS OF

course of the electric current is always as it is shown to be in the diagram, that is, it leaves the battery at the copper end, and enters at the zinc.

We have now before us the means of obtaining a supply of that description of electricity of which we stand in need, and we can, by a very simple experiment, illustrate the principle of action on which the whole of the operations of the Electric Telegraph depend.

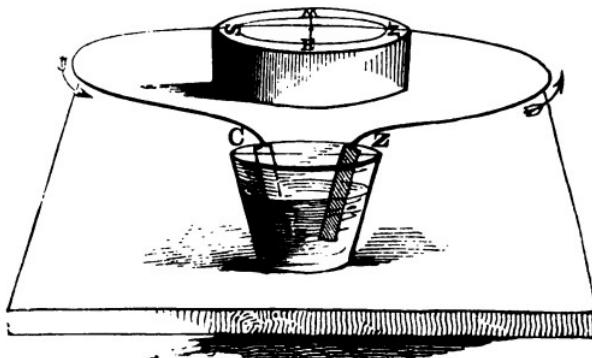


FIG. 5.

Let us now take a mariner's compass and lay a wire directly over the needle, then fasten one end of the wire to the zinc screw, and touch the copper with the other end, the *needle immediately moves from the north, and*

THE ELECTRIC TELEGRAPH.

takes up a position at right angles with the wire, but the instant we remove the end of the latter from the battery, or *break contact* as it is called, the needle returns to its original position, and if we turn the battery end to end, so that the copper shall be connected with that end of the wire, which, in our last experiment, was screwed to the zinc, on *making contact*, the needle, as in the first instance, moves from the north, but in the opposite direction, and we shall find that by making the wire pass over several needles, they will all be equally and simultaneously affected, no matter how long the wire, or how far apart, the needles may be ; and if instead of simply laying the wire over the needle, we wind it several times round the case in which it moves, taking care the sides of the wire do not touch each other, we shall much increase the effect.

We have now obtained the power of moving magnetic needles in whatever direction we please, and at any distance apart from each other, exactly at the same instant; for, as we have already seen, the speed with which Electricity travels, is too great for human calculation. If we now arrange with a correspondent

ORIGIN AND PROGRESS OF

that certain movements shall represent certain letters, we can communicate intelligence to him; in fact, we have made an Electric Telegraph.

In practice, however, a vertical needle is more convenient than a horizontal one, and it is absolutely necessary so to contrive that the needle shall be deprived of its tendency to point to the North, and yet retain its magnetism unimpaired.

This is effected by placing two needles on the same axis, with the North end of one opposite to the South of the other. They will



thus counteract each other, and yet be equally well affected by Electricity. Their lower ends are made slightly heavier than the upper, so that they may regain their perpendicular position, after having been moved. (See fig. 6.)

We have already said that if the wire by which the electricity is conducted, is wound round the case that Fig. 6. supports the needle, its power of acting on it is very much increased. Accordingly a very thin copper wire, covered

THE ELECTRIC TELEGRAPH.

with silk or cotton to prevent contact between the sides of the wire, and about two hundred yards long, is wound round a double frame of metal or wood, and the needles so suspended that one shall be between the two coils, and the other outside the dial plate to serve as the index or pointer. Fig. 6 is a side view, and fig. 7 a back view, of the needles and coils. In fig 6, A, A, are the needles, B the coils of wire, and c the dial. In the next diagram, fig. 7, the coils and needle are more distinctly

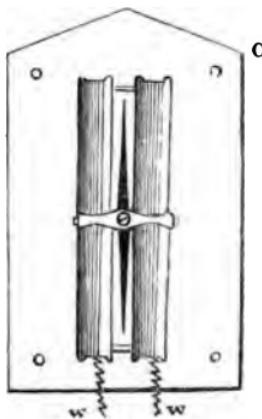


FIG. 7.

shown, and w, w, are the ends of the coil wire
in connection with the battery. If the right

ORIGIN AND PROGRESS OF

hand wire of this coil is connected with the copper end of the battery, and the left with the zinc, the index points in one direction, but if the battery wires are reversed, the needle moves in the opposite direction. Ivory pegs are placed on the dial to limit the deflection of the needle, and by moving a handle attached to the instrument, the battery communication can be changed at pleasure.

The next thing to be effected, is to convey the electricity to a distance. Every railway traveller knows, we presume, that this is effected by means of the wires which are supported by poles, placed at intervals along one side of the road. These are generally erected about sixty yards apart, or thirty in the mile, so that the speed of the train is easily found by counting the number of poles passed in a minute and multiplying by two, which, of course, gives the rate per hour. Each pole, it will be observed, is provided with earthenware tubes, or insulators, through which the wires pass : earthenware, we must remember, is a non-conducting body. These insulators are for the purpose of preserving each wire from connection with any of the others, and for pre-

THE ELECTRIC TELEGRAPH.

venting any communication between them and the earth, which in wet weather would take place, the wet pole then forming a conductor, and interfering with the passing current of Electricity.

The passage of the electric current to any distance, being thus insured, an instrument with coils, needles, &c., similar to that just described as placed at the terminus of the railway, is fixed at the other extremity, the connections with the wires being so adjusted that the needles at both stations may move in the same direction at the same time. A question will here suggest itself, How does the electricity find its way back again to the point from which it started? In the Telegraphs as at first constructed, a separate wire was led along the line for this purpose, the current being conducted along one wire, and, having done its work, it was led back by another, but the expense of the double wire was heavy, and cheapness being the order of the day in scientific as well as in other affairs, it was necessary to resort to some other means.

It had been discovered that the earth itself was a good conductor, why, then, might it not

ORIGIN AND PROGRESS OF

answer the purpose of the return wire, and thus save so large a portion of the expense ? All that was required was, that a connection should be made with it at each end of the line, the earth thus forming part of the circuit. To effect this, the return wire from the instrument is joined to a gas or water pipe, or to a buried metal plate large enough to present a surface of four or five square feet.

It is at first sight incomprehensible how a current leaving a battery at Newcastle, and one starting from Southampton for London, should each find its way safely back to the place it left like a sagacious dog. So it is, however ; and that with unerring certainty, and as far as our senses are concerned, instantaneously.

To account for this singular fact, some imagine the earth to be a reservoir of Electricity, infinite when compared with any quantity that can be added to, or taken from it, and, therefore, the battery merely adds to it at one end of the circuit, and subtracts from it at the other. Others suppose the effect of the battery merely sets the natural Electricity of the circuit *in motion*, so that like a jack towel or an

THE ELECTRIC TELEGRAPH.

endless chain, the moving of one part of the circuit drags round the remainder.

Thus far it has been supposed that only the two terminal stations require to communicate with each other, but intermediate stations must not be neglected, many of them being of great importance. The main wire opposite each of these stations is cut through, and an insulator inserted between its two ends, rendering it impossible for any current to pass. A wire is now fastened on one side of this insulator and led into the station, where it is connected with an apparatus like that already described, care being taken that the current shall enter the coil apparatus in the same direction as it does at the two terminal stations, while the other end of the coil is attached to a second wire, which is led outside and fastened to the main wire on the other side of the insulator, and thus the broken current is again complete, having been merely diverted from its regular course to leave a message at the station as it passed by.

The annexed diagram, fig. 8, will explain this arrangement: one intermediate station only is shown, but in practice the same apparatus is *set up* at all the principal stations. Two needles

ORIGIN AND PROGRESS OF

are used at each station, although in the diagram one only is seen represented.

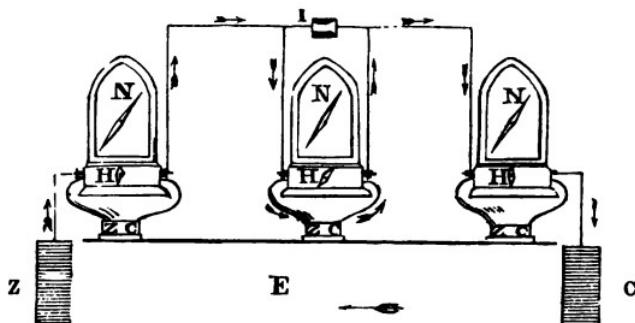


FIG. 8.

The handle of the centre instrument is observed to be turned towards the right hand. This brings the battery into the circuit, and causes the current to pass. If we suppose it turned in the opposite direction, the current will flow the contrary way.

Letter *i* is an insulator, *e* the earth, and the arrows show the direction of the electric current, *n*, *n*, *n*, are the needles, *h*, *h*, *h*, the handles by which the connection between one part of the circuit and another is either broken or made, and *z* and *c* show the zinc and copper ends of the batteries, which we have already described.

THE ELECTRIC TELEGRAPH.

The early Telegraphs had a great number of needles, and of course the same number of wires. These were then reduced to five needles, afterwards to two, constituting the double needle system, and ultimately to one, the single needle system. We have already seen that the needles at the various stations are completely under control, and that by making contact with the battery, those at distant stations may be caused to move in concert. The motion of the needle in different directions indicates particular letters or words. To make this more intelligible, we must refer to a representation of the dial of the double needle system.

It will be seen that the letter **A** is repeated twice on the dial, **B** thrice, and these letters are indicated by moving the needle over which they are engraved as many times towards them as they occur on the dial. When the letters are placed below the needles, both needles are used, thus :

ORIGIN AND PROGRESS OF

	LONDON.	CAMBRIDGE.	ELY.
X	3	4	7
 C ¹  D E		H L ⁵  M N	
AA	FF	II	OO
BBB	GGG	KKK	PPP
NOT UNDER- STAND	UNDER- STAND	FIGURES	CODE
2 NO!	2 YES!	2 LETTERS	2 PRIV. SIGS.

COOKE & WHEATSTONE,
1837.

8		≡
 R u ⁹  v W		
SS		XX
TTT		YYY
WAIT		GO ON

For A, move *left* needle twice to the left,
 For E, move *left* needle once to the right. For I,
 move *right* needle twice to the left. For P,
 move *right* needle thrice to the right. For S;

THE ELECTRIC TELEGRAPH.

both needles together once to the left. A double movement is required for *c*, *d*, *l*, *m*, *u*, and *v*, first away from the letter, then towards it, pausing a moment on the second movement.

Thus *c* is once to the right, then once to the left, with the *left* needle; *m* once to the left, then once to the right, with the *right* needle; *u* *both* needles, first to the right, then to the left, (the *lower* ends are here referred to.)

A slight pause is made after each letter; and at the end of each word the left needle is moved once towards the cross *, to indicate that the word is finished. If the correspondent understands the word, he points the left needle once to the right, and the next word is given; if he does not understand, he moves the needle once to the left, and the word is repeated. A separate code has been contrived for figures, but it has been found better to spell the words out. Of course all the needles in the circuit move simultaneously, and the message can be read at all the stations at the same time.

Before the attendant at any station begins to send his message, it is necessary that the clerk at each station should be aware that his attention *is required*; and for this purpose a bell

ORIGIN AND PROGRESS OF

is rung by a means we will presently describe.

We have already seen that when a magnetic needle is placed in the centre of a coil of wire, through which a current of Electricity is passing, that it is powerfully affected ; now if this needle had been a piece of soft unmagnetised iron, it would have become endued with all the properties of a magnetic needle, although these properties would not have been permanent. This effect is more strongly shown if we send a current of Electricity through a covered wire coiled round a bar of pure soft iron, which at once becomes a magnet, but as soon as the stream of Electricity ceases to pass through the coil, it becomes again a mere bar of soft iron, without any attractive power.

The bar is made in the form of a horse shoe to bring the poles of the magnet near to each other, and a piece of soft iron, or "armature," is suspended on a lever or spring, so as nearly to touch the poles of the magnet. The principle, but not the exact form, of this apparatus, is shown in the annexed diagram :

THE ELECTRIC TELEGRAPH.

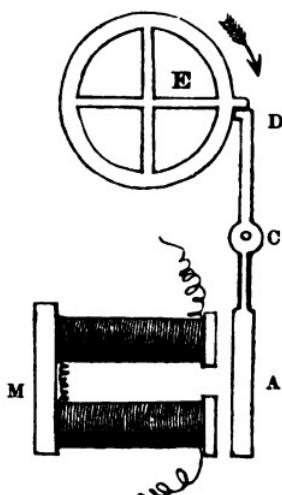


FIG. 10.

M is the horse shoe bar of iron, or rather two cylinders of iron joined by a connecting piece, round which the covered wire is coiled: A is the soft iron armature, which is attached to a lever moving on a centre at c. When a stream of Electricity is passed through the coil, the horse shoe bar becomes a temporary magnet, the armature is attracted, and the lever moving on its centre at c, drags back the detent D, by which the wheel E was locked. This wheel being thus set at liberty, a common alarum is at once put in motion, and

ORIGIN AND PROGRESS OF

the bell rings until the spring has run down, or until the horse shoe magnet loses its power from breach of contact between the coil and the battery. As soon as this takes place, the armature being released, the detent D again locks the toothed wheel, and the alarm stops.

As we now understand the means by which the Double Needle Electric Telegraph conveys information, we will illustrate the subject further by supposing London E , Cambridge H , and Ely N , to be three stations in the same circuit; the first name will be engraved over the letter E , the second over H , the third over N . If London wants Cambridge, he rings the bell, and points the needle repeatedly to H ; the clerks at each station look at their dials, and Cambridge repeats the signal. London gives his own name, or letter E , to show who wants Cambridge; Cambridge repeats it, and shows he is aware London wants him; the message is then sent and each word is acknowledged as received. When the message is completed, the stop $*$ is given twice slowly, and the answer is returned.

If an enquiry has to be made before the answer can be given, the signal "wait" is in-

THE ELECTRIC TELEGRAPH.

dicated by holding the needles for a second to the letter R, as shown on the dial. Ely could have read the signals, but would not take the trouble, unless they were intended for him. This inconvenience of disturbing every station when one only is wanted, is common to all Telegraphs, unless each has a separate bell wire as on the Norfolk line, on which the Telegraph is carried out more perfectly than on any other, and there no station is rung excepting that which is wanted.

Several plans have recently been contrived, one by which an intermediate station can either ring up or down the line, that is, the stations, either to the right or to the left; another, which is hardly perfected, will probably give the same facility with one wire as that gained on the Norfolk Railway with separate wires for each station. The common rate of signalling in ordinary business is about fifty letters a minute, but a good hand can read sixty or even sixty-five. On several lines an electro-magnetic machine, by which a current is derived from a permanent magnet, is used with great success for ringing bells. This has been named by a facetious railway porter, “ a

ORIGIN AND PROGRESS OF

thunder pump." It is more certain in its action than a battery.

We have hitherto spoken of the Electric Telegraph as a means of conveying messages from station to station for various purposes, but as a further illustration of the subject, let us refer to the mode in which the movement of the various trains is indicated on the Yarmouth and Norwich Railway, for instance, which is a single way, by following (on the Telegraph) a special, and, therefore, an unexpected, train, from Norwich to Yarmouth.

Instruments similar to fig. 11 are placed at each of the five stations whose names appear on the dial.

"A fixed time," observes Mr. Cooke, "say five minutes before the train leaves Norwich, the superintendent having first ascertained that the line is clear at the next station, will ring the Brundall alarum. He then turns his Norwich handle to the left, (see fig. 11,)

THE ELECTRIC TELEGRAPH.

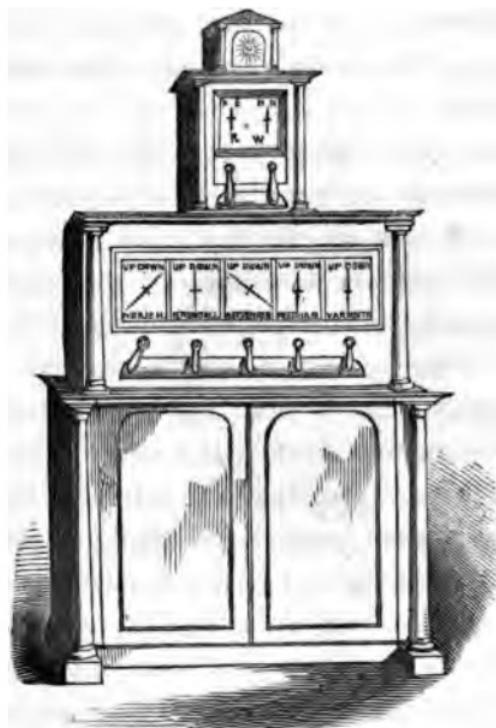


FIG. 11.—NORWICH RAILWAY APPARATUS.

the signal for ‘down train.’ This movement causes a corresponding indication by the system of Norwich pointers at all the stations, and thus informs the clerk at Brundall, and the other stations of the line, that a down train is about to start if the line is clear: if it is

ORIGIN AND PROGRESS OF

clear the Brundall clerk, whose attention has been called by the alarm, announces the fact by giving the same signal upon his own compartment.

"The train being now ready, the Norwich superintendent gives the usual order to start, and as the engine moves forward, he restores the handle of his Telegraph to its upright position again. The pointers of the Norwich system then, by becoming vertical, give notice to the other stations that the 'down train has left Norwich,' and is on its way to Brundall. This serves as a warning to the clerk at Buckenham, the station beyond Brundall, to give the signal, 'down train,' in his compartment of the Telegraph, that the clerk at Brundall may be prepared to notify to the train upon its approach, that the line is clear to Buckenham.

"Presently the train is seen approaching Brundall, and if not intended to stop at that station, leave to proceed is given to the conductor in the usual way, and the clerk at the same time puts down the handle of his compartment, whereupon all the pointers of the Brundall system resume their vertical position, and announce to the other stations that the

THE ELECTRIC TELEGRAPH.

down train has passed Brundall and is on its way to Buckenham, and the same routine is repeated throughout if the line is clear."

In the representation we have given of the Norwich Apparatus, the needle of the Norwich compartment is set for "down train," and that of the Buckenham for "up train," showing a train as having started from each end of the single line. As many as four trains have been on the line at once, and no accident has ever occurred.

It is interesting to mark the progress of the train by the needles being "set" one after the other. This can be seen on any Telegraph station on the Norfolk line—one almost *sees the train itself*.

For the practical application of the Electric Telegraph, we are indebted to Messrs. Cooke and Wheatstone, both of whom had for several years been making experiments on the subject, and in 1837 they entered into partnership with each other, since which time many improvements have been introduced by which the Electric Telegraph has been brought to its present state of perfection.

ORIGIN AND PROGRESS OF

MECHANICAL TELEGRAPHS.

THE PRINTING TELEGRAPH.

The Printing Telegraph, (see engraving,) invented, we believe, by Mr. Rouse, an American, and patented in England by Messrs. Brett, appears to be the most complete instrument of this kind yet produced. The failure of the attempts made in England to compass that great desideratum—a permanent registering of the information telegraphed—arose from the endeavour to make the electricity itself work the printing apparatus. But this was found impracticable. A large proportion of the electric force is lost in the passage of the current through the long and imperfect circuit formed by the wire and the earth; and what remains is insufficient to produce the amount of electromagnetic power requisite for such a purpose.

The apparatus we are now about to describe, owes its success to the adoption of an entirely different principle. The apparently insurmountable difficulty has been rather avoided than overcome; and that, too, by a plan which,



ELECTRIC PRINTING TELEGRAPH.

THE ELECTRIC TELEGRAPH.

from its very simplicity, was likely to be overlooked. Instead of being worked by the electric current, the printing apparatus is set in motion by ordinary mechanical power, obtained from weights acting in a similar manner to the weights of a clock, and all that is required of the electric current is to set these weights at liberty, or, to speak in mechanical language, the electricity works the *escapement*. The idea was probably suggested by the arrangement of a clock or a watch, in which the pendulum and the main-spring act the part of escapements. In the case of the clock, it is manifest that the very slight force expended at each vibration of the pendulum, is sufficient to set in motion the whole machinery, simply by permitting the motive force of the weights to come into play; and it is obvious that Electricity might be readily made to play the same part in the Telegraphic Printing Machine.

Proceeding to a more detailed explanation, we will first describe the manipulating station of the Telegraph, that is, the end at which is stationed the official who conveys the information. This consists principally of a brass cylinder or barrel, about two feet long, and

ORIGIN AND PROGRESS OF

four inches in diameter, which is made to revolve at a moderate velocity by means of weights. On one end of this barrel are fixed as many cogs as there are letters in the alphabet, and upon these cogs presses a spring, so arranged as to touch but one cog at a time, and that only as it passes under its end. This spring and toothed barrel form part of the electric circuit, the current having to pass from the spring to the barrel and thence to the wires; and the result is, that during the revolution of the barrel, the spring in touching each successive cog or tooth, completes the circuit, and in the interval between the touching of one cog and the next following, the circuit is broken.

Arranged along the top of this barrel, but not touching it, are a number of keys similar to those of a piano, each marked with one of the letters of the alphabet, as in fig. 12; and on the under side of every key is a projecting stud or knob, so fixed that when the key is depressed, a corresponding stud on the barrel is caught by it. These studs on the barrel correspond with the cogs at its extremity, and their position is such that at the moment when

THE ELECTRIC TELEGRAPH.

one of them is arrested, the cog answering to it comes in contact with the above-mentioned



FIG. 12.

spring, and so long as the key is kept down, the electric current continues unbroken.

Proceeding to the other end of the Telegraph at which the information is received and printed, we observe, first, a common electromagnet around which the extremity of the Telegraph wire is coiled. This magnet is of course perfectly inert, except when the electric current is passing, and then it becomes active. Adjacent to its extremities is placed a moveable *keeper*, (the name given to the piece of iron

ORIGIN AND PROGRESS OF

commonly attached to the end of a magnet,) which is drawn down whenever the magnetic force is generated, but is pulled away again by an attached spring whenever the electric current is interrupted. By this alternate movement of the keeper—a movement, as before observed, analogous to a pendulum or balance wheel—the escapement is worked, and each oscillation to and from the ends of the magnet disengages the wheel work of the printing machinery, and allows the suspended weights to turn the type wheel one cog in advance. This type wheel has twenty-six little arms or spurs projecting from its circumference, each of them carrying one of the letters of the alphabet, and in the course of the wheels' revolution, each letter in its turn comes in contact with a little inking roller, which prepares it to make an impression.

Near to the circumference of the type wheel, is placed the paper carrier, a small cylinder round which is coiled the strip (like a riband round a bobbin) on which the messages are printed. This cylinder is capable of moving bodily up against the type wheel whenever an impression is to be made, and a further arrangement causes it to revolve through a small

THE ELECTRIC TELEGRAPH.

space at every movement, so that the impression of each letter shall follow the preceeding one as in ordinary printing.

The reader is now prepared to understand the action of the apparatus. Calling to mind the arrangement at that end of the Telegraph from which intelligence is conveyed, it will be seen that so long as no key is pressed down, the barrel will continue to revolve, and that by means of the spring and cogs at its extremity, it is continually completing and breaking the electric circuit. At the other extremity of the Telegraph, the electro-magnet being rendered alternately active and inert by the completion and breaking of the current, is constantly attracting and letting go the moveable keeper, and by so doing, it allows the machinery to revolve, cog by cog, so that the barrel at one end having been made to correspond with the type wheel at the other, (the proper cog answering to the proper letter,) the two will continue revolving together step for step as long as they are allowed to do so. Now it will be seen that if the paper carrier moved up against the type wheel at each advance, it would be continually printing the alphabet.

ORIGIN AND PROGRESS OF

over and over again. An ingenious hydraulic contrivance is, therefore, employed by which a certain short time (perhaps half a second) is made to elapse before the machinery that moves the paper cylinder begins to act. The consequence is that the type wheel, which advances when let alone at a greater velocity than this, (perhaps at the rate of four letters per second,) never allows the paper cylinder time to be moved up against it, and so long as the apparatus is not interfered with, the machinery will go on while the motive power lasts without a letter being printed.

It will now, however, be remembered that when one of the keys at the manipulating end is pressed down, it stops the barrel as soon as the cog answering to that key comes round, and that the stoppage is so managed that the electric current continues complete as long as the key is depressed. But during the continuance of the electric current the electro-magnet at the other end remains constantly active, and by holding fast the escapement checks the revolution of the type wheel, and this type wheel, having been made to correspond with the *barrel* at the other station, presents to the

THE ELECTRIC TELEGRAPH.

paper cylinder at the moment of its arrest, the same letter as that marked on the key of the manipulating apparatus, and the type wheel being thus, for an instant, brought to a stand, the paper cylinder moves up against it and receives the impression of the letter presented. The operator at the other end then proceeds to the next letter in the message he is sending, and the same movements are repeated.

It is said that this apparatus will print at the rate of eighty-seven letters per minute. It did not, however, perform at this rate when we saw it, but it was not in perfect order.

The advantages of the system are manifestly very great. Perhaps the greatest is that the information is duly printed and delivered by the machine, even though there may be no official present to receive it.

The Printing Telegraph has, indeed, many advantages if it could be worked with certainty. This, however, is not yet proved, but it has also many disadvantages: it is of little use printing a message unless it is seen and read at the time; a clerk *must*, therefore, be in attendance in this case, as closely as when the needle, or dial and pointer, are employed.

ORIGIN AND PROGRESS OF

Again the machinery is necessarily complicated, and liable to get out of order. The Dial Telegraphs, also, have the same imperfection; but the needle arrangement is so simple that unless a wire is broken, or the needle demagnetized, it cannot fail. Its only parts being two needles hung on fine pivots, a coil of wire, and a lever, with two springs to make and break the battery contact.

Then again, so long as the battery can but just move the needles, the signals can be read, though they will not be strongly marked: but so soon, in a mechanical arrangement, as the battery power falls below a certain point, the wheels will no longer move: they must either work well or not at all; but the needles will act well, indifferently, and badly, and as the power decreases, they give notice by their slower and more feeble movements that the battery requires attention. In fine, the mechanical Telegraphs are decidedly the most elegant in appearance, but, at present, the needle must be considered as the most certain in its operation.

A company has lately been formed, called *the "Electric Telegraph Company,"* for the

THE ELECTRIC TELEGRAPH.

purpose of establishing a connected series of Electric Telegraphs throughout the country, with a grand central terminus in London. By this means information can be conveyed in a few seconds from every part of the kingdom. We hardly need notice the vast benefit this would confer on the commercial community, and in case of war, how much it would facilitate the operations of Government in the movement of troops, and how quickly orders might be despatched to every part of the coast.

It seems, also, as if there was great probability of its being introduced into large establishments and even private houses, for the purpose of giving orders to servants or workmen. An apparatus of this nature may be seen at the present time at work in the new Houses of Parliament, serving as a means of communication between the different Committee Rooms. It is curious to notice the changes that have taken place in private dwellings in the means of communication between different parts of the building : first, we had the hand-bell to summon a domestic ; then the house bell rung by the bell rope attached to the *bell wire*, which was led through the house

ORIGIN AND PROGRESS OF

in various directions, assisted by its long train of cranks and levers; and, lastly, the Speaking Pipe. A very pretty code of signals might be got up for the occasion to imply, "take away the roast," "bring up the dessert," "another bottle of wine," "coffee," "muffins," anything you choose, and all done without noise and with half the labour to the attendant.

BAIN'S NEW SYSTEM OF ELECTRO-TELEGRAPHIC COMMUNICATION.

The specification of a very ingenious plan of communicating intelligence by the Electric Telegraph was enrolled by Mr. Bain in June 1847. A certain number and arrangement of holes, punched in a long slip of thick paper, are made to indicate certain letters of the alphabet, thus:—

THE ELECTRIC TELEGRAPH.

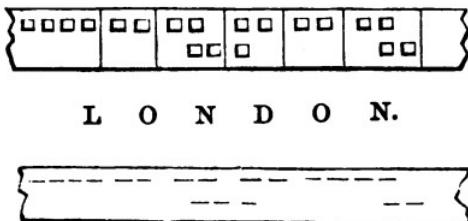


FIG. 13.

The holes punched in the thick paper as shown in the diagram, represent the letters L O N D O N, and, consequently, the word London. At the station transmitting the intelligence, the whole message is, in the first instance, punched out upon a long slip of thick paper, and this thick paper is then rolled round a wooden roller A. This roller is free to move

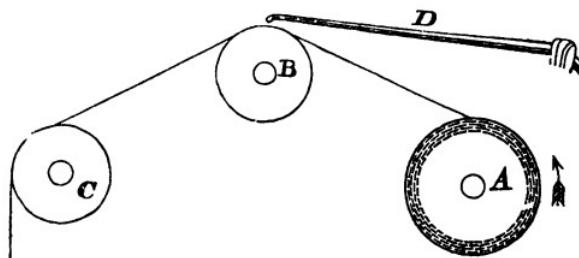


FIG. 14.

ORIGIN AND PROGRESS OF

in the direction of the arrow ; the paper passes also over a roller, *B*, which is moved by clock-work, unrolling the paper and passing it in over roller *C*. The roller *B* is of metal ; *D* is one of two metallic springs, placed at such a distance from each other as to rest immediately over the double series of holes before described ; consequently as the rollers turn round, and the paper passes over the roller *B* ; the extremities of the springs fall into the holes as they pass beneath them, and each time the spring touches the metal roller, a communication is formed with the battery, and a current of Electricity passes along the wire of the Telegraph with which the roller *B* is in contact.

At the other end of the line, where the communication is received, an apparatus of a similar nature is placed, but “ instead of the strip of perforated paper, there is wound round the roller *A*, a strip of coloured paper which has been first soaked in dilute sulphuric acid, and afterwards in a solution of prussiate of potash, this is wound upon the roller *A*, while yet in a wet or damp state, in which state it forms part of the voltaic circuit, and

THE ELECTRIC TELEGRAPH.

must, therefore, be kept damp while the communication is being transmitted.

" Matters being in this state, and the machine at both ends of the line being placed in metallic contact, the attendant at the transmitting apparatus sets it going: this has the immediate effect of lifting a detent in the recipient apparatus at the other end of the line, and thereby setting it going also, that is to say, the two machines commence simultaneously unrolling the slips of paper attached to them respectively. As long as contact is prevented between the springs **D**, and the roller **B**, of the transmitting apparatus, by the interposition of the entire parts of the roll of paper, the passage of the voltaic current is interrupted or broken; but the instant the ends of either of the springs drop into one, two, or more of the holes in the paper, the voltaic circuit is re-established, and the electric current passing through these holes, travels along the connecting wire, and through the wet roll of paper at the other end of the line, discharging in its passage the colour from the paper in those parts which it penetrates, and thereby leaving *as many legible spots on the wet roll of paper*

ORIGIN AND PROGRESS OF

as there are holes in the diagram. In this manner it will be seen that as many spots will be left on the slip of prepared paper at the recipient station as there were holes punched in the slip of thick paper at the opposite extremity of the line. Sometimes, however, it is requisite that the party at the recipient station should not understand the contents of the communication. In such cases the recipient paper is merely wetted with dilute sulphuric acid, and then passed through the apparatus in the manner above described, after which the words can be rendered legible by immersing the paper in a solution of prussiate of potash.

By this means, after the holes have been punched in the paper, the message may be sent in an extremely short time. The holes can be punched with great rapidity by an experienced hand, punches in fact might be formed by which the symbol of each letter could be cut at one blow. "Thus," observes the Editor of the "Mechanics' Magazine," "supposing a communication to be once punched in paper, and the paper to be committed to the transmitting apparatus, it will require but a few minutes to convey that communication to any

THE ELECTRIC TELEGRAPH.

distance however great, and that, too, in as complete a form as any letter, despatch, circular, or pamphlet, is now conveyed by post. We foresee the perfect practicability in this way of all the leading articles of the ‘Times,’ for instance, being re-printed and re-published in Liverpool, or Glasgow, or Edinburgh, simultaneously with their publication in London.”

Another great advantage of this new method is, that the actual transmission of the message will occupy a very short time, so that with the same number of wires a far greater amount of business may be done than by any other method, the preparation and reading of the message being done by clerks.

MORSE'S TELEGRAPH.

This variety of the Electric Telegraph is employed on all the American lines. It is a species of Printing Telegraph, and acts in the following manner: A kind of style, or pen, leaves an impression on a yielding substance; the style is brought down upon, or raised from, this substance by the agency of a soft

ORIGIN AND PROGRESS OF

iron temporary magnet; a momentary impression of the style leaves the mark of a simple dot; a longer continuance of the action, a shorter or longer line, according to the time it remains in contact; different arrangements of lines and dots express certain letters or words; the scroll of the soft substance that receives the impression is kept in slow motion by means of clock work, and in this manner a message of any length is impressed, and can be rapidly read off. Nearly two thousand miles of wire, it is said, are already laid down for telegraphic communication of this nature.

BRETT AND LITTLE'S ELECTRIC TELEGRAPH.

In this newly patented Telegraph, the indicators are entirely detached from that portion of the apparatus through which the electric current is made to pass; and instead of being deflected by the passage of the electricity, they are moved by means of levers pressing against a pin fixed in the back of each indicator.

THE ELECTRIC TELEGRAPH.

These levers are connected with two “partially magnetized rings,” which are themselves moved by the passage of a current of Electricity through coils of wire on the same principle as in the Electric Telegraph at present in use.

By this arrangement, it is said, that the indicators are not subject to derangement by the action of atmospheric Electricity, by which, during the passage of thunder storms, the needles of Telegraphs of the present construction are occasionally affected.

The battery by which the Electricity is excited, has been called the “hydraulic battery,” in which the acid is supplied to the sand in the battery trough, drop by drop, and escapes from the latter in the same manner. The acid liquid thus constantly running off, carries with it the sulphate of zinc as fast as it is formed, and before the solution becomes sufficiently concentrated to crystallize on the plate, and impede the action of the acid.

It is, perhaps, right to explain that when instruments are shown in a room as working through ten, a hundred, or a thousand miles of wire, that a fine wire is used, one mile of which is calculated theoretically to offer a resistance

ORIGIN AND PROGRESS OF

equal to a hundred or five hundred miles of the galvanized iron wire used in practice. No allowance is made for joints or for bad insulation, both of which occur, of course, on a Railway.

THE SUBMARINE TELEGRAPH.

The restless spirit of modern invention, not content with guiding the mysterious power of which we have been speaking, both above and beneath the surface of the earth, with more certainty and ease than the best rider can rein his gentlest palfrey, proposes next to join the shores of England and France by means of a Submarine Telegraph, across the Straits of Dover. That such an undertaking is possible, there is but little doubt; but the question is, would it be worth while to attempt to carry it out.

If a wire could be covered so as to protect it perfectly from the water, and if it could then be lowered into the sea so as neither to be *injured* by the currents, or by ships dragging *their* anchors, the object would be accomplished.

THE ELECTRIC TELEGRAPH.

and there is no practical difficulty in doing this for a short distance, as from East to West Cowes, or even, perhaps, for greater distances, but the injuries to which the wires would be subject, appear to create almost an insuperable objection to this plan being carried out on a large scale.

THE DIAL TELEGRAPH.

We employ this term in contra-distinction to Needle Telegraph, although they are both Electric Telegraphs. In those arrangements of signals that exhibit the letters of the alphabet painted on a dial, the electro-magnet pulls round the wheel work by which the dial is moved, by means of a ratchet wheel and catch, one tooth at a time.

The Needle Telegraph, and that invented by Brett and Little, as we have seen, have alphabets of their own, which must be learned before they can be read.

The double needle code (before described) is very easy. Any one of moderate ability *can send a message after an hour's practice, but*

ORIGIN AND PROGRESS OF

to *read* one well requires about ten days attendance in the office. It has been learned in a day.

The single needle code is slower, but many persons learn it even more readily than the double.

PHENOMENA, ANECDOTES, ETC.

So wonderful a discovery as the means of conveying information silently and invisibly from place to place, is a subject of such supernatural interest, that we might readily be led to expect some strange effects would be produced upon the minds of the uninformed, and if we are to believe all the stories that have been told on the subject, this has been the case. One man imagined that the wires were hollow, and that papers on which the communications were written, were blown through them. Another man, more acute than his neighbours, knowing that sound was more readily conveyed through a tube

THE ELECTRIC TELEGRAPH.

than a penny post letter, decided that they were speaking tubes: nay, a man in the north, who one day had got near the line, declared that he heard the message “as it went through them pots,” (the insulators).

A labourer at Lincoln walked three miles to see the man run along the wires with the letter bags.

An old gentleman imagining he had left his umbrella behind him at the last station, wished to have it “telegraphed.” This was immediately done, and in about a minute the porter told him it had possibly arrived, and requested him to look out and see; this he did, and sure enough it was hanging upon one of the wires. The old man was thunderstruck, and hastened away from the spot were such “uncanny” practices were going on, for he firmly believed he had left it behind him, and that by some trick akin to magic, it had been returned.

The Electric Telegraph has proved of great service in many instances in the cause of justice, by giving information of the flight of a criminal, in time to reach a distant station before the man himself.

ORIGIN AND PROGRESS OF

A cunning butcher was in this way deceived : he wanted to take his dog with him without paying. The railway officials would not allow of this, but he called the dog, and it got into the carriage. The butcher, it seems, had no great faith in the rapid and off-hand way in which the Telegraph performed its duties. He laughed with his fellow passengers at the "cute" manner in which he had "done" the railway. "They could not *telescope* him," he said, "before he got to Birmingham." In this, however, he was grievously disappointed, and on his arrival thought himself lucky in escaping by merely paying the fare for his four-footed companion.

When the Steam Engine for filling the water tanks was first put up at the Newark station, the man who worked it told me that a party of ladies looked in at the door, and after hesitating some time, one of them asked if "this were what worked the Telegraph." He crammed them to the best of his ability, and he says people frequently ask him the same question.

A conscientious clerk in the north left his place when he was required to work, and de-

THE ELECTRIC TELEGRAPH.

clined the task, saying "he would not have any dealings with the evil one."

"A correspondent," observes the Editor of the "Athenæum," "in glancing through the volumes of the 'Spectator,' has marked a passage in No. 241 of that work, which he thinks worth bringing under our notice, as offering a curious example of a matter treated by an enlightened writer of the time as a piece of fabulous extravagance, yet more than realized in one of the most extraordinary applications of modern science:—'Strada, in one of his prolusions, gives an account of a chimerical correspondence between two friends by the help of a certain loadstone,—which had such virtue in it that if touched by two several needles, when one of the needles so touched began to move, the other, though at ever so great a distance, moved at the same time and in the same manner. He tells us that two friends, being each of them possessed of these needles, made a kind of dial-plate, inscribing it with twenty-four letters—in the same manner as the hours of the day are marked upon the ordinary dial-plate. They then fixed one of the needles on each of these plates in such a

ORIGIN AND PROGRESS OF

manner that it could move round without impediment so as to touch any of the twenty-four letters. Upon their separating from one another into distant countries, they agreed to withdraw themselves punctually into their closets at a certain hour of the day, and to converse with one another by means of this their invention. Accordingly, when they were some hundred miles asunder, each of them shut himself up in his closet at the time appointed, and immediately cast his eye upon his dial-plate. If he had a mind to write anything to his friend, he directed his needle to every letter that formed the words that he had occasion for—making a little pause at the end of every word or sentence, to avoid confusion. The friend, in the meanwhile, saw his own sympathetic needle, moving of itself to every letter which that of his correspondent pointed at. By this means, they talked together across a whole continent, and conveyed their thoughts to one another, in an instant, over cities or mountains, seas or deserts. * * In the meanwhile, if ever this invention should be revived, or put in practice, I would propose that upon *the lovers' dial-plate* there should be written

THE ELECTRIC TELEGRAPH.

not only the twenty-four letters, but several entire words which have always a place in passionate epistles;—as flames, darts, die, language, absence, Cupid, heart, eyes, hang, drown,—and the like. This would very much abridge the lover's pains in this way of writing a letter—as it would enable him to express the most useful and significant words with a single turn of the needle.' "

We have already spoken of the inconceivable rapidity with which Electricity moves, and that it may be said to occupy no time in its passage, but problematical as it may appear, instances may arise in which it would be literally true to say it occupied "less than no time." The Telegraph at New York in America, might report a speech spoken at that place, and it might be taken down in writing at the station at Buffalo, five degrees distant, the true time at the latter place being twenty minutes earlier than the time by the day at the place where it was spoken, so that it would be literally true that it might be recorded before it was spoken. This, of course, would arise from the difference in longitude between the two towns.

The first Electric Telegraph of any extent

ORIGIN AND PROGRESS OF

completed in England, was that between London and Portsmouth. When it was completely finished, all engaged on it were naturally anxious to ascertain whether the Electricity would safely travel through the earth to so great a distance, and whether the connection was complete. The signal was given from the London station, and every eye was fixed upon the needle, but no answer was returned; the signal was repeated, but still unsuccessfully; a third time it was tried, and the needles at length began to move; the letters were taken down as fast as they were signalled, and the result was,—“fast asleep by the fire.” It is needless to say that there was no alarm attached to the apparatus to awaken the drowsy clerk, who, it is to be hoped, was ever afterwards wide awake.

Some of the phenomena attached to the passage of the Electricity along the wires, and particularly in stormy weather, are worth noticing. It was imagined by many, when the fearful nature of the electric fluid was considered, that the clerks would be endangered by the atmospheric Electricity being carried into the offices by the wires during thunder storms;

THE ELECTRIC TELEGRAPH.

but hitherto, in England at least, no accident or inconvenience has happened from this cause. The precaution, however, has been taken in this country by placing a pointed wire connected with the earth at every winding post, by which the wires are supported above ground; and a system of knobs and points is placed at every station to protect the instruments. In America, Professor Henry states, the wires have frequently been struck, and the poles knocked down along the lines of the railway, and a succession of sparks has passed between the two wires for more than an hour.

Occasionally, in England, the fine wire of the coils has been fused, and the polarity of the needles has been frequently reversed, or the magnetism destroyed, but no further accident has happened. The bells often ring violently during a thunder storm, and sometimes, though but seldom, the lightning tries to send messages for itself, but these have never yet been decyphered.

The needles are sometimes steadily deflected during calm weather, and generally, if two instruments are connected to wires running severally North and South, their needles will

ORIGIN AND PROGRESS OF

point in opposite directions. No effect of this kind has, we believe, been ever noticed on the Yarmouth and Norwich line, where the wires have a direction of East and West. All inconvenience from this is very easily remedied by placing a small permanent magnet in front of the needles, which restores them to the vertical. Mr. Barlow's investigation of this phenomenon, establishes its relationship to the daily variation of the compass, and throws much light on terrestrial magnetism. His paper was read at the late meeting of the British Association, and will be published in the Transactions of the Royal Society.

Many persons believe that when small birds perch on the wires, they are likely to be killed by the shock when the Telegraph is worked, and a speculative man has calculated how long it will be before the thievish sparrows are cleared off by this dread means. That this is not the case, is proved by the fact that many scores of martins may be seen sitting together on the wires close to their nests, apparently not feeling the slightest inconvenience, nor will they be disturbed by the longest message.

In America many birds are killed by atmos-
76

THE ELECTRIC TELEGRAPH.

pheric discharges, and at times, Professor Henry states, they are to be seen hanging to the wires by their claws. But in England those found dead have met with their fate by flying violently against the wires. On one occasion a bird was picked up which had struck its beak against the wires, and broken its neck. The plate layers, aware of this, make a practice in some places of frightening partridges, and trying to make them cross the line in order that they may kill themselves.

In windy weather the wires act like a powerful æolian harp, and make a continued humming noise, which is considered to be made by the message as it passes along, and more than one man has put his ear to the post, or climbed it to listen, attributing his want of success to his ignorance of the language used.

The following list exhibits, we believe, the length of the various lines of Telegraph in England at present completed, and also those which are in progress:—

ORIGIN AND PROGRESS OF

LINES COMPLETED.

	Miles.
South Western	99
South Eastern	88
Ramsgate Branch.....	30
Margate Branch	4
Maidstone Branch	10
Tonbridge Wells Branch....	6
Bricklayer's Arms Branch ..	6
Blackwall	5
Eastern Counties, Colchester line	51
Thames Junction	3
Cambridge Line	88
Hertford Branch	7
Ely and Peterborough ...	29
Eastern Union	17
Norfolk Railway	38
Yarmouth and Norwich ..	20
Wolverton and Peterborough	57
Midland Counties, South Line	49
West Line	41
North Line	73
Derby and Lincoln	49
Sheffield Branch	5
York and North Midland	23
Hull and Selby and Milford Extension ..	40
York and Scarborough	43
Great North of England	45
Richmond Branch..	9
Newcastle and Darlington	39
Durham Branch ..	2
Sunderland Branch ..	5
Shields Branch ..	8
Preston and Wyre	20

THE ELECTRIC TELEGRAPH.

	Miles.
Sheffield and Manchester (Woodhead Tunnel)	3
Great Western	19
South Devon	20
London and Croydon	8
Bristol and Birmingham	$90\frac{1}{2}$
Leeds and Bradford	16
South Eastern, Deal Branch	9
Norfolk Railway, Lowestoft Branch	10
————— Dereham Branch	13
Leeds and Manchester	61
Newcastle and Berwick	60
—————	
	1,310$\frac{1}{2}$
—————	

LINES IN PROGRESS.

Syston and Peterborough	40
Leeds and Bradford	15
Hull and Bridlington	27
South Devon	27
Syston to Melton Mowbray	12
London to Rugby	83
—————	
Total in Progress.....	204
Total Completed	$1,310\frac{1}{2}$
—————	
Total	$1514\frac{1}{2}$
—————	

AMERICAN TELEGRAPHS.

Albany to Buffalo	350
New York to Boston	220

ORIGIN AND PROGRESS OF

	Miles.
New York to Albany	150
Washington	230
Washington to Baltimore	40
Baltimore to Philadelphia	97
Philadelphia to New York	88
New York to New Haven	84
Newhaven to Hartford	30
Hartford to Springfield	20
Springfield to Boston	98
Albany to Rochester	252
 Total	 1,659

THE ELECTRIC CLOCK.

For the first application of Electricity as the motive power in clocks, we are indebted to Mr. Bain of Edinburgh, and the chief advantage to be derived from this invention consists in the production of an uniformity of action in an indefinite number of clocks when connected with each other. The patent by which this invention is secured, is now the property of the Electric Telegraph Company. The annexed *diagram* is a representation of an Electric *Clock*,

THE ELECTRIC TELEGRAPH.

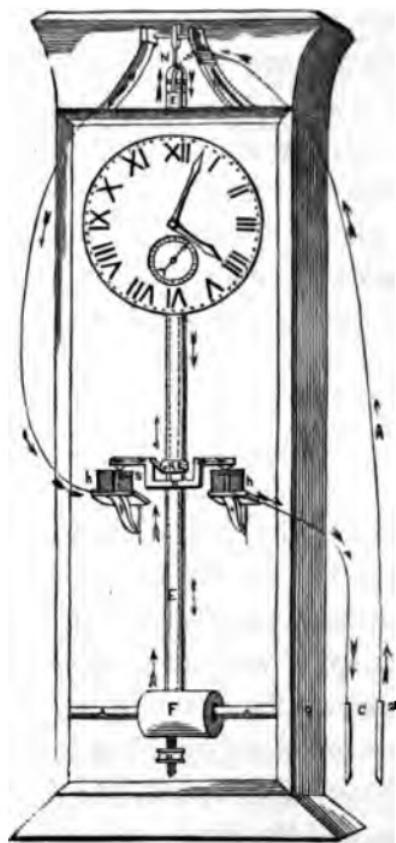


FIG. 15.

showing the mode in which the current of Electricity acts on the pendulum. In this case, instead of the battery used for the Tel

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